Vol. XLV. JUNE. 1901.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
INSTITUTED 1852.

TRANSACTIONS.

No. 895.

THE PRESERVATION OF RAILWAY TIES IN EUROPE.

By O. CHANUTE, Past-President, Am. Soc. C. E.

PRESENTED OCTOBER 17TH, 1900.

WITH DISCUSSION.

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England took the lead in preserving timber by chemicals more than one hundred years ago. Her wooden ships forced this subject

upon the attention of her builders and chemists, and thousands of experiments were tried with scores of substances. M. Paulet, in his book, "Conservation des Bois," enumerates 173 processes or methods. Most of them have proved failures, but some four or five proved to have value, as stated in the report of the Committee to this Society in 1885.

These four or five processes were brought into practical use, especially after the "Railway Era" rendered the preservation of ties an important economy, but all antiseptics, save tar-oil, have now been abandoned in England, where "creosoting,"* so-called, has grown to be recognized as the best process to use. Practically all the ties (they call them sleepers) now laid in Great Britain are treated. A few, cut in Scotland, are laid in their natural state, but at least 90% are imported and creosoted.

Mr. S. B. Boulton, author of a paper awarded the Telford medal by the Institution of Civil Engineers in 1884, and universally recognized as the best British authority on the subject; Mr. A. Ross, Chief Engineer of the Great Northern Ry.; Mr. C. L. Morgan, Engineer of the London, Brighton & South Coast Ry.; Mr. Harry Footner, Engineer of the London & North Western Ry., and others, have kindly furnished the writer with data concerning modern British practice, from which the following account has been compiled.

Almost all the sleepers are of "Baltic redwood" from Russia, Sweden and Norway. They are cut in the late autumn or winter, and summer cutting is generally barred in the specifications. The tie makers are generally engaged in farm work during the summer. When the spring and summer floods occur, the sleepers are floated and rafted down the streams to the shipping ports, much of the sap being washed out by this procedure. The logs or ties are then shipped to English ports, arriving some four to six months after felling, and they are frequently left to soak in water until sawed. They are generally imported as "Blocks" or "Balks," cut to a length of 9 ft., and squared to 10 ins., requiring sawing in two, which many railways specify must be done only at the port of delivery. After being made into sleepers, generally 8 ft. 11 ins. long, 10 ins. face and 5 ins. thick, containing 3.11 cu. ft., they are stacked in cribs, with 4-in. spaces between the sleepers and with sloping top layers,

* Creosote, properly so-called, is a medicinal product of vegetable distillation.

and allowed to season from 4 to 6 months more. Thus they are from 10 to 12 months, and sometimes 18 months, old when "creosoted."

Many of the railways have their sleepers adzed and bored for the fastenings by machinery before creosoting, while others do this by hand in laying. It is conceded that boring before treatment is good practice, but sometimes inconvenient when several patterns of chairs are used.

The specification for creosoted sleepers of the London, Brighton & South Coast Ry. is given herewith, in Appendix A, as fairly representing British practice. The mode of injection is practically the same on all roads; the "Bethell" process is used, in which there is no previous steaming, as the sleepers are already well cleared of sap, and seasoned, but the quantities of tar-oil injected and the results differ a little on various roads.

From an elaborate report of M. V. Herzenstein, presented to the International Railway Congress in London, 1895, giving data obtained from about half of the British railways, Table No. 1 has been compiled by the writer. The kind of timber is omitted, as it is almost all "redwood"; and the reported cost, reduced to our money, is only applicable where long contracts previously existed, as tar-oil has much advanced in price since 1894, when the data were gathered. This advance has been due to its increasing recognition as the best timber preservative. Some years ago it was so cheap that it was used as fuel, and while the normal price in England (so far as a fluctuating commodity can be said to have a normal price) was about 4 cents per gallon, it is now 7 cents per gallon, hard to find, and with indications of going higher. The present price increases the cost of creosoting very materially from the prices given in the table.

Most of the railways are getting their creosoting done by contract, but the London and Northwestern is doing its own work, and reports the cost at 20 to 25 cents per sleeper. It also reports the longest life (16 to 20 years), save the London, Tilbury and Southend, which is a small road, of light traffic. The British are not injecting nearly as much tar-oil as the French roads, and they obtain a lesser life, as will be shown later.

Many of the results obtained with sleepers in England are due to the system of track. The rails are of the "Bull-head" type, laid on chairs with about 108 sq. ins. of bearing surface, and hence there is no

TABLE No. 1.—ABSTRACT OF ANSWERS OF BRITISH RAILWAYS TO MR. HERZENSTEIN.

Number.	Railway.	Number of sleepers annually renewed.	Process of preservation.	Amount injected.	Reported cost. 1894. Cents.	Life, in years.	Cause of failure.
I.....	Belfast and N. Counties Ry............	....	Creosoting.	1 gall. per cubic foot.	12	15	Splits.
II....	Furness Ry..........	40 000	"	8 lbs. per cubic foot.	15	15	
III...	Hall Barnoley Ry...	4 000 to 24 000	"	8 lbs. per cubic foot.	......	......	
IV....	Great Eastern Ry...	90 000 to 100 000	"	2½ galls. per tie.	16	12–15	Wear.
V.....	Great Northern Ry..	....	"	0.7 gall. per cubic foot.	13	12	
VI....	Great Southern and Western Ry.	....	"	3¼ galls. per tie.	......	......	
VII...	London and North Western Ry.....	300 000	"	30 lbs. per tie.	......	16–20	Wear.
VIII..	London and South Western Ry.....	170 000	"	2½ galls. per tie.	18	12	Wear & splits.
IX....	London, Tilbury and Southend Ry.	Variable.	"	7 to 10 lbs. per cubic foot.	......	25–30	Decay, etc.
X	Manchester S. and L. Ry............	20 per mile.	"	10 lbs. per cubic foot.	......	16	40% Decay.
XI....	Midland Ry..........	....	"	....	......	......	
XII...	North British Ry....	....	"	1 gall. per cubic foot.	14	......	
XIII..	North London Ry...	....	"	28 lbs. per tie.	......	15	
XIV..	South Eastern Ry...	97 000	"	28 lbs. per tie.	......	8–9	Wear.
XV ..	Taff Vale Ry........	17 000	"	1¼ galls. per cubic foot.	30	15	Natural causes.

Particular attention is called to the quantities (28 to 30 lbs.) of creosote injected per tie. The creosote used practically conforms to the specifications of Dr. Tidy, published in Mr. Boulton's paper, of 1884, and is to be entirely free from water, bone oil, shale oil, or other inferior oils.

cutting by the foot of the rail. The fastenings consist of trenails, of round drift bolts called spikes, and of lag screws, and are thoroughly effective.

FRANCE.

France, which was once so abundantly wooded, has been partly denuded, the present area of the forests being estimated at about one-fifth of what it was in the days of Julius Cæsar. The forests have, moreover, been culled, yet they furnish about 3 000 000 ties annually to the French railways, leaving about 1 000 000 to be imported. Of the aggregate about 2 600 000 ties per annum are now consumed in renewals, and it is a notable feature that the number renewed has been diminishing for the past 15 years,* in spite of the fact that the mileage to be maintained has been constantly increasing.

* The renewals averaged 3 072 605 ties per annum for the eight years 1878 to 1885 inclusive.—H. Mathieu, in *Revue Générale des Chemins de Fer*, August, 1887.

This result, which has been estimated as producing an annual economy of about $3 000 000 to the French railways, has been wholly due to the impregnation of the ties and to constant improvements in the processes. The French began treating wood about 1837 by the "Boucherie" process of expelling the sap by hydraulic pressure, using sulphate of copper as an antiseptic. Many of the railways took this up, but most of them abandoned it about 1878, and the only road which had continued the use of this substance, the "Midi," has now finally given it up in favor of creosote. The latter substance is now practically used exclusively by all the roads, save those of the State, which use a mixture of chloride of zinc and creosote, which will be more fully noticed when the German practice is described. "Burnettizing," *i. e.*, the injection of chloride of zinc alone, has been extensively used, but is now abandoned, as the zinc is found to wash out in time, especially in moist situations.

The kinds of wood used in renewals and construction have approximately been in the following proportions: Oak, 60%; beech, 22%; pine and sundries, 18 per cent. Of these, the supply of oak is diminishing, and the use of beech and pine is increasing. Formerly, the creosoting of oak was confined to sappy ties, but now all oak is treated, although but small amounts of tar-oil can be forced therein. The quantities of this substance injected have steadily been increased. While the British railways were content with 22 to 30 lbs. per tie, the French railways injected from 31 to 40 lbs. in beech and pine, with correspondingly better results in duration, and they have lately still further increased the amounts. Thus the "Ouest" Railway now requires 44 lbs. per tie; the "Est," which does its own work, injects 60 lbs. of tar-oil per tie, and the "Paris, Lyon et Mediterranée" follows the practice of the "Est."

The results heretofore attained upon the French railways are given in Table No. 2, which is compiled from Mr. Herzenstein's report, already quoted. It will be noticed that the life obtained is considerably in excess of that in England, and is nearly in direct ratio to the quantities injected and to the cost incurred. As this treatment is applied to beech ties, which cost some 70 cents each unprepared; to pine, costing 60 cents each, and to oak, costing from 95 cents to $1.10 each, it is seen that thorough injection produces important economies.

TABLE No. 2.—ABSTRACT OF ANSWERS OF FRENCH RAILWAYS TO MR. HERZENSTEIN.

No.	Railway.	Number of ties annually renewed.	Kind of wood.	Process of preservation.	Amount injected.	Cost. 1893. Cents.	Life, in years	Causes of failure.
XXVII...	State	161 213	Pine.	Zinc. Creosote.	66 lbs. per tie.	....	10–15	Decay.
"	"	....	Oak.	Zinc. Creosote.	9 lbs. per tie.	....	......	
XXVIII..	Eastern........	356 650	Beech.	Creosote.	60 lbs. per tie.	42	25–30	Wear.
XXIX....	Meridional.....	10%	Oak.	None.	....	....	......	
XXX.....	Southern.......	284 511	Pine.	Sulphate of copper	0.4 lb. dry per cubic foot.	....	8–10	Decay and Wear.
"	"	....	Oak.	Creosote.	9.5 lbs. per tie.	....	10–15	Since increased.
XXXI....	Northern......	285 000	Oak.	Creosote.	11 lbs. per tie.	11	......	
"	"	....	Beech.	Blythe Process.	24 lbs. per tie.	21	......	Going over to straight creosoting.
XXXII...	Western.......	242 050	Oak.	Creosote.	11–13 lbs. per tie.	....	15–20	Decay and Splits.
"	"	....	Beech.	Creosote.	31–33 lbs. per tie.	....	18–25 (?)	Now inject 44 lbs.
XXXIII..	Orleans........	460 000	Oak.	Creosote.	12 lbs. per tie.	....	15	Decay.
"	"	....	Pine.	Creosote.	35–44 lbs. per tie.	30	13–16	"
XXXIV..	Paris, Lyon & Mediterranean	700 000 (?)	Oak.	Creosote.	10–11 lbs. per tie.	12	12	Decay and cutting.
"	"	....	Beech.	Creosote.	26–35 lbs. per tie.	18	Prior to 1890.	Now copies Eastern.

All the French roads but one have been creosoting by the "Bethell" process. The exception, the "Nord," has been using the "Blythe" process, which consists in first heating the wood with a mixture of steam and creosote vapor, and then injecting by pressure about 24 lbs. of liquid tar-oil per tie. This method was adopted to economize the amount of this costly substance used. The specifications of this road are given in Appendix B, but the Chief Engineer of Maintenance of Way, Mr. Agnellet, when handing these to the writer, stated that the quantity of creosote injected had lately been increased to 35 lbs. per tie, and that the present cost was 35.6 cents, as against 21 cents per tie in 1893. The road will probably go over to straight creosoting, and adopt the methods of the "Est" Railway, which is recognized as doing the best work of that kind.

The "Est" Railway does its own creosoting, and has two plants with an aggregate capacity of over 500 000 ties a year. It purchases chiefly oak ties (95 cents), and beech ties (65 cents), upon rigid specifications, carefully enforced, and piles them up at its works to season. The piles are isolated and contain 100 ties each, with 10-in. air spaces between the sticks, and the top layer is made of sawed ties laid close and sloping. These piles are inspected from time to time, and if cracks appear a hoop-iron S is driven in at the end, or a hole is bored and a bolt with washers is inserted. Oak ties are thus seasoned 15 to 20 months, and beech ties 6 months or more, and are further desiccated before treatment in special drying ovens from 60 to 80 hours. Repeated weighings show that the oak loses 16% of its weight in 12 months, and 2.7% more in the drying oven, while the beech loses 25% in 10½ months, and 3.5% more in the ovens. The use of the latter is deemed important, not only to expel remaining moisture and to ensure regularity of treatment, but to obviate the chilling of the hot tar-oil upon its admission. For this purpose, the ties, loaded upon buggies, are run direct from the ovens, where the final temperature is 176° Fahr., into the treating retort, whereupon, without previous steaming, a vacuum of 26 ins. is produced, and the tar-oil then admitted. Before going into the drying ovens the ties are adzed for rail seat and bored for lag-screw fastenings. This is done by steam machinery, at a cost of 2 cents per tie.

The time occupied by a treatment is 2½ hours for oak and 3 hours for beech, of which time ½ hour is under a pressure of 75 lbs. per square inch for oak, and 1 hour of the same pressure for beech, the tar-oil being admitted at a temperature of 176° Fahr. Under these conditions, the oak ties absorb from 14.22 to 16.65 lbs. of creosote each, and the beech ties take from 59.40 to 66.60 lbs. each. More could be forced into the latter, but this has been found sufficient, being, it will be noticed, double as much as is injected in England.

Every invoice of creosote is chemically tested at the works. The requirements are: (1) That it shall be greenish in hue. (2) Naphthalene not over 30%. (3) Distillation not to begin below 392° Fahr. Moreover, there should be 10% of carbolic acid (and attending water) and 10% of green oil, the density of the whole being 1.05 to 1.10 specific gravity. This tar-oil comes generally from the Paris Gas Co., but the specifications cannot be rigidly enforced just now, for

tar-oil is so scarce that the engineers have to accept what they can get. The total cost of treatment is 33.8 cents per tie for oak, and 64.2 cents per tie for beech, as stated by M. V. Dufaux, Engineer of Maintenance of Way, of the "Est" System, who kindly gave the writer his elaborate paper, published in "*Revue Générale des Chemins de Fer*" in January and March, 1898. This cost is about double that on other roads, but the results are correspondingly good, the creosoted oak lasting 25 years, and the creosoted beech being estimated to last 30 years in the track, as evidenced by data for 27 years, these data also showing that untreated oak lasts about 15 years.

The road uses "*Vignoles*" or foot rails, and, as already intimated, fastens them to the ties by lag-screws. Tarred tie-plates, of animal felt, have heretofore been in use, but are now replaced by creosoted poplar tie-plates, which cost less than 1 cent each, and are said to be giving perfect satisfaction. Two dating nails are driven in each tie, one at the works, and the other when laid in the track.

Germany.

By far the largest proportion of wooden ties laid in Germany are home grown, and almost all are chemically treated before laying. The raw ties of the first class are generally 8 ft. $10\frac{1}{4}$ ins. long, $10\frac{1}{4}$ ins. face and $6\frac{5}{16}$ ins. thick, and cost $1.32 to $1.49 each for oak, and 82 to 90 cents for pine. White beech costs about $1.00 per tie, and red beech is in controversy. About 500 000 oak ties are creosoted annually, and about 1 600 000 pine ties are treated annually with chloride of zinc and creosote for the Prussian State Railway, the whole of Germany probably taking about double those quantities. The German specifications are very strict, and the raw ties are minutely inspected. If there are incipient cracks, a sharpened band of hoop iron, bent into the shape of an S is driven in, and the ties are piled up in isolated piles, well ventilated, to season in the receiving yards at the treating works. There they remain, with casual inspection and more driving in of S-irons, or insertion of bolts if required, from 8 to 12 months before they are treated, having in the meantime become perfectly seasoned.

At the beginning of the "Railway Era" each railroad company in Germany erected its own works and treated its own ties, either with corrosive sublimate, with sulphate of copper, with chloride of zinc or

with creosote, but gradually there was an evolution which curiously recalls that of the Pullman Car Company in the United States. Mr. Julius Rütgers' father, who had learned the business in some French tie-treating works, erected a plant or two, took his son in with him, and did so much better work than the railroads did for themselves that the business gradually came into his son's hands. At the present time, Mr. Rütgers controls some twenty plants, while the Prussian State Railroad has four, and there are five more in other hands.

The general officer in charge of maintenance of way on the Prussian railways told the writer that although the State treated ties at its own works somewhat cheaper than Mr. Rütgers, yet the latter had so much better facilities and controlled the proper quality of chemicals so thoroughly, that it was preferred to give him most of the work by contract, and to operate the State plants as a check. The original reason seems to have been that the railways which did their own work attempted undue economies by skimping the chemicals and employing cheap men, while Mr. Rütgers made a specialty of the business.

Corrosive sublimate and sulphate of copper are now practically given up in Germany, and the State Railway also abandoned Burnettizing or the injection of chloride of zinc by itself in 1897. There are now three processes in use:

(1) Impregnation with chloride of zinc and tar-oil.

(2) Creosoting after seasoning and drying in ovens.

(3) Creosoting after desiccation in hot tar-oil.

The latest German specification (1898) for the first and third of these processes is given in Appendix C. The method of desiccating in hot creosote, although introduced by Mr. Rütgers, was originally proposed by Mr. S. B. Boulton, in England, in 1885.

As the German railways did not answer the questions of Mr. Herzenstein, no such tabular statement can be given as those given herein for England and France, but through the kind assistance of Mr. Rütgers, of Privy Councillor Wetz, of M. F. Holbein, and many others, the important facts were gathered, and access was obtained to many tie-treating plants.

The most notable thing in Germany is the painstaking care with which every operation is performed. The ties are not treated until they are thoroughly seasoned, this generally taking six months to one year after cutting and piling in open piles in the yards, most of which

yards will hold one year's supply. The chemicals are tested constantly, a laboratory being attached to each plant, each buggy load of 32 ties is weighed before and after treatment, to make sure that the ties have absorbed enough, and every little while each individual tie of a buggy load is weighed in and out. Thermometers are consulted constantly, and automatic recording gauges preserve a diagram of the vacuum and pressures attained, as well as of their duration; the ties are allowed to dry after treatment before they are placed in the track, and, after they get there, well bedded in deep ballast, further care is exercised to see that they are well drained. The result is that ties prepared by the zinc-creosote process, mostly pine, now last from 12 to 18 years, and creosoted ties, mostly oak, are expected to last from 24 to 28 years. In past time it was not always thus, some beech ties creosoted having perished about as soon as some ties injected with chloride of zinc alone, but the results developed upon the roads in Alsace-Lorraine, where beech ties, creosoted by the French, were found to be sound after 21 years of exposure, have again brought the Germans to favor the use of beech creosoted, there being a surplus of that timber, heretofore disesteemed, in the forests of that country.

An able paper by Mr. A. Schneidt, formerly Superintendent of the Alsace-Lorraine Lines, published in the German Railway Organ in 1896 and 1897, shows that the chloride of zinc undoubtedly leaches out of the ties in time, and he advocates the creosoting of beech wood, either by the process of boiling in hot oil, or by the zinc-creosote process. He shows that the former is the more economical of the two, notwithstanding its greater cost, taking in view the high first cost of the untreated ties in Germany.

The prices paid in Germany for treatment, when reduced to American currency, are shown in Tables Nos. 3 and 4.

TABLE No. 3.

Timber.	With Zinc Chloride.		With Zinc Creosote.	
	1st class. Cents per tie.	2d class. Cents per tie.	1st class. Cents per tie.	2d class. Cents per tie.
Pine	15.60	12.00	19.20	14.40
Oak	12.00	9.12	15.60	12.00
Beech	18.80	12.48	20.40	15.36

TABLE No. 4.

Timber.	With Creosote and Drying Oven.		Boiling in Creosote.	
	1st class. Cents per tie.	2d class. Cents per tie.	1st class. Cents per tie.	2d class. Cents per tie.
Pine	53.76	40.32	56.64	42.00
Oak	26.85	20.16	28.80	21.60
Beech	56.64	42.00	59.28	44.40

These prices are based upon the various amounts of the antiseptics which the different woods absorb, with careful work. As already stated, treatment with chloride of zinc alone has been given up, and boiling in creosote is growing in favor, as computations of annual charges for the renewals exhibit the fact that, notwithstanding the higher cost, impregnation with tar-oil is the most economical, in the long run.

In days gone by, some parties asked for guarantees before having ties treated by the zinc-creosote process, and in such cases Mr. Rütgers guaranteed the following lives:

Guarantee A.	Guarantee B.
95% to last.....10 years.	95% to last.....10 years.
80% " .....11 "	75% " .....11 "
70% " .....12 "	65% " .....12 "
	50% " .....13 "
	25% " .....14 "

In computing the results, 5% of all ties treated is first deducted, to cover internal diseases which even the strict German inspection cannot detect, and the guarantee applies on the remainder alone, Mr. Rütgers agreeing to make the deficit good to the extent of either refunding the treatment price paid per tie, or treating another tie free of charge, at his option. He charges extra a bonus of 10 pf., or 2.40 cents, a tie for this, and in the case of Guarantee B an extra bonus of 10 pf., or 2.40 cents, a tie a year, for every year's life over the guarantee. In point of fact the character of his work is now so well established that his customers prefer to save the bonus and take their own chances as to life of ties.

Particular attention is called to the German specifications for creo-

sote, and to the amount of chloride of zinc injected in connection therewith. The latter amounts to ½ lb. dry, per cubic foot.

The leading features of tie treatment in Europe are, therefore, the following:

1. Close inspection of raw ties, rejecting all defects.
2. Thorough seasoning for 6 to 12 months before treatment.
3. Constant testing of chemicals; strength, purity, etc.
4. Injection of liberal quantities of the chemicals.
5. Minute care in all the stages of impregnation.
6. Drying the ties after injection.
7. Methods of fastenings superior to our own.
8. Deep ballast, and thorough drainage.
9. Marking with dating nails, and careful records.

United States.

Thus it appears that the Europeans are now getting a longer service out of their ties than is obtained in the United States, Mr. Curtis having shown, in his paper* read before this Society May 17th, 1899, that an average life of 10 to 12 years is being obtained by the use of zinc chloride in this country. It would be possible to obtain a life of 15 to 30 years by the use of creosote, but it will be seen, from the figures given, that this would cost three to four times as much as zinc chloride. Thus, at present prices, it would cost 45 cents each to creosote according to English practice, and 15 to 16 years' life would be obtained; it would cost about 85 cents each to creosote after the best French or German practice, and 27 to 30 years' life would be obtained in thoroughly drained ballast; but it would not be economical to spend such sums upon ties costing 20 to 40 cents each untreated, while it is economical to spend them upon ties costing from 90 cents to $1.50 each abroad.

We must be content, therefore, either to allow our cheap ties to decay in the good old way, or to adopt for the present some of the cheaper and inferior methods which will produce shorter lives than obtained in Europe. By the light of past experience, those cheaper methods may be said to be three in number: 1st, straight Burnettizing; 2d, the zinc-tannin process, and 3d, the zinc-creosote process.

* *Transactions*, Am. Soc. C. E., Vol. xlii, p. 288.

The writer is satisfied that the zinc-tannin process, as modified by himself in 1896, is superior to straight Burnettizing, and that the record of the next few years will demonstrate this, yet he is desirous of doing still better work, and he went abroad chiefly to investigate the zinc-creosote process. He now thinks that it is probably superior to the zinc-tannin process, although part of the greater life shown by records is attributable to other causes, such as the better ballast and drainage, and the better modes of fastening, as well as the climatic conditions. There are, however, some serious difficulties to be overcome before the process can be introduced here. Suitable tar-oil, as described in the specifications of Appendix C, is just now very scarce and high in price, so high that the freight, the leakage and the cost of the barrels render the cost almost prohibitory. The writer took over with him two samples of American creosote from different makers, and had them analyzed in Berlin, where they were pronounced by Mr. Rütgers' chemist quite unfit for tie preserving by the zinc-creosote process. The writer brought back samples of the German tar-oil, and is now endeavoring to procure a similar product in this country. He is also investigating, so far as he can, the merits of various new processes which are being advanced from time to time, with the hope of finding some method which he can recommend.

The principal dilemma, with reference to new processes, is the fact that it takes half a business lifetime (15 to 18 years) to ascertain beyond peradventure whether an antiseptic or a method is thoroughly efficient to preserve ties in the track; yet it may be possible by isolating the bacteria and fungi which are most destructive to wood, and inoculating chips and shavings with the cultures, to draw some approximate conclusions in the course of a few months. Meanwhile, it is recommended that the railroads shall give trial orders to the various parties who offer plausible processes, and then expose the treated ties in such locations as admit of careful record and watching of the results.

The principal new processes are as follows:

1. *The Creo-Resinate Process.*—This process was described in a paper presented to this Society by F. A. Kummer, Jun. Am. Soc. C. E., on June 6th, 1900.* He proposes the use of creosote and resin, both preservative substances, to which a small percentage of formal-

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* *Transactions*, Am. Soc. C. E., Vol. xliv, p. 181.

dehyde is to be added. It may be questioned whether the latter volatile substance will stay in the wood, but the process is well worth trying, provided sufficient quantities of the chemicals are injected.

2. *The Water-Creosote Process.*—This consists in injecting an emulsion of creosote and water, and is being experimented with in Berlin. The writer expects to have samples sent to him this year.

3. *The Hasselman Process.*—This consists in boiling the wood in a solution of the sulphates of copper and iron, with alumina and "Kainit." It possesses the merit of being cheap, and some ties prepared in that way have now been three years in the yard tracks in Berlin. Works have been started at Perth Amboy, N. J., to work this process.

4. *The Allardyce Process.*—This consists in the injection of chloride of zinc, followed by a second injection of tar-oil. A similar process was patented by the late J. P. Card, Assoc. Am. Soc. C. E., in 1882, but neither he nor the writer, who subsequently became his partner, ever succeeded in doing good and regular work therewith, notwithstanding many experiments.

5. *The Naphthenic Acid Process.*—This consists in injecting the wood with a solution of copper which has been dissolved in an acid obtained by a peculiar process in the distillation of Russian petroleum. It is stated to be theoretically effective and cheap, but American petroleum differs so much from the Russian in chemical constituents, that it is yet a question whether the naphthenic acid can be produced in this country.

Laboratory tests are sometimes misleading. They show, for instance, that bichloride of mercury and sulphate of copper, as antiseptics, are superior to chloride of zinc, and yet the latter preserves ties better. So with carbolic acid, which is stated by Mr. Boulton to be less efficient than the heavy oils of creosote. Such criticism, however, does not apply to the laboratory tests of the strength and purity of the materials used, and there are three features of the European practice which it would be well to imitate in this country. They are the following:

1. The careful testing, chemically, of the antiseptics to be injected.

2. The uniform injection of the wood with stated and liberal quantities of the antiseptics.

3. The adequate seasoning of the wood before treatment. This is

now generally neglected in the United States, and yet it is the most important requirement in obtaining good results, for, otherwise, the antiseptic will not be uniformly distributed, and some portions of the ties will decay before others.

Originally, at the works of the writer, ties were treated in the order of their arrival, and without regard to their condition. The result was that in 6 or 7 years some were found to decay much in advance of others. Experiments, made by weighing considerable numbers of individual ties before and after treatment, disclosed the fact that there were great differences in the absorption, and in later years arriving ties have been tested, sorted out, and seasoned in case of need, so as to obtain uniformity of treatment, with the result that the average absorption of chloride of zinc is now two and one-half times as much as it was 14 years ago.

From his experience, the writer is satisfied that if the ties are injected with reasonable uniformity and with the equivalent of ½ lb. of dry zinc-chloride to the cubic foot, as is done in Germany, straight Burnettizing makes them last 10 to 12 years in the track, with ordinary exposure; while perhaps half of that quantity will produce the same result in the more arid regions of the United States; that the new zinc-tannin process will impart to them a life of 12 to 14 years, and the zinc-creosote process may extend this to 14 or 16 years.

It cannot, however, be too strongly insisted upon that the work must be well and skillfully done, for, otherwise, the results are sure to be disappointing.

APPENDIX A.

LONDON, BRIGHTON AND SOUTH COAST RAILWAY COMPANY.

Specification and Conditions of Contract for Creosoted Redwood Sleepers.

1. This proposed contract is for the supply and delivery of
................sleepers at Deptford Wharf,
................sleepers at Newhaven Wharf,
or any less number that the Directors may decide to accept.

2. The dimensions are to be the customary 9-ft. length (say $8\frac{11}{12}$ ft.) 10 by 5 ins. rectangular, cut from square blocks out of which neither more nor less than two sleepers can be sawn (no centers will be accepted).

3. The quality shall be the best Baltic redwood fir in good condition, free from shakes, dead knots, and other defects.

4. Sixty per cent. of the sleepers to have on one side a flat surface not less than 9 ins. wide throughout the length, and the remainder to have on that side a flat surface not less than 8 ins. wide throughout the length. All sleepers to have a flat surface not less than 10 ins. wide on the other side with sharp edges throughout the length.

5. Ninety per cent. of the sleepers to have not less than $8\frac{1}{2}$ ins. and the remainder not less than 7 ins. diameter of heart at both ends.

6. The blocks from which the sleepers are cut must be of last autumn's deflotation at the port of shipment; any delivered of an earlier deflotation will be rejected.

7. The sleepers are to be cut and stacked from four to six months (or until they are considered sufficiently dry by the Company's Engineer or his Inspector) before they are creosoted. They are to be adzed to a true plane for a width of 17 ins. at each end for the chair seating, and 40%, or such other percentage as may be required, are to be bored with eight holes, namely, two $1\frac{1}{8}$ ins. diameter at each end (for trenails) and two $\frac{5}{8}$ in. diameter at each end (for spikes). A template, showing the position of these holes, will be provided by the Company, and the Contractors must bore the holes exact to it, and perfectly true through the sleepers.

8. The sleepers will be inspected at the Contractor's wharf before being creosoted, and the Engineer shall have power, personally or by deputy, to reject any sleepers he may consider inferior, either in quality of timber or from any deviation from the specification, and his decision in the matter shall be final.

9. The sleepers, when sufficiently dry, are to be placed in a wrought-iron cylinder, and when closed a vacuum is to be created by air-pumps. The creosote, at a temperature of 120° Fahr., is to be allowed to enter the exhausted cylinder, and afterward maintained there by pumping at a pressure of not less than 120 lbs. to the square inch. The sleepers are to be kept under this pressure until each sleeper has absorbed at least 3 galls. of creosote on the average, the quantity to be ascertained by weighing.* Any charge of sleepers not giving the average impregnation of at least 3 galls. to be returned to the cylinder for further treatment.

10. The creosote to be a pure coal-tar distillate of the very best quality, free from water and all impurities, and on analysis to give the following results:—

> To be entirely liquid at a temperature of 120° Fahr., and remain so on cooling to 93 degrees.
>
> To contain not less than 25% of constituents that do not distil over at a temperature of 600° Fahrenheit.
>
> To yield, to a solution of caustic soda, not less than 6% by volume of tar acids.
>
> The specific gravity at 90° Fahr. to range between 1.040 and 1.065, water being taken as 1.000 at the same temperature.

11. The Contractor is to supply a copy of the analysis of each delivery of the creosote oil used, in the terms of the Specification, and the Engineer shall be at liberty to take samples of the oil from time to time and have the same tested, the Contractor paying the cost of the analysis to the extent of one analysis for each 10 000 sleepers. Any additional analysis to be made at the Company's expense.

12. Delivery shall be made alongside the Company's New Haven and Deptford wharves, at either of the rates mentioned below, at the option of the Company's Storekeeper, until the Contract is completed. Delivery at Deptford will be taken by open barges containing not more than 1 800 sleepers each. The craft to take regular turns for discharging, and conform to the regulations of the Company's wharves:—

At Deptford—To commence .... and
continue at the rate of .... sleepers per week.
At Newhaven—To commence .... and
continue at the rate of ....sleepers per week.

13. Should the Contractor fail to deliver the sleepers, or any portion of them, as stipulated in Condition No. 12, the Directors may cancel the Contract or the residue thereof, and obtain other supplies in such manner as they think fit, and the Contractor shall pay to the Company any extra cost and expenses incurred by such failure, or the

* In practice one trolley is weighed out of each charge.—O. C.

Directors may deduct the amount from any sum then due or becoming due to the Contractor.

14. The shipping port or ports must be named in the Tender; and if more than one port, the number of sleepers proposed to be shipped at each port must also be given. Bills of lading to be produced by the Contractor when required.

15. The price per sleeper is to include every charge except wharfage and landing at the Company's wharves.

16. For sleepers delivered and approved during one month, payment will be made at the Company's next monthly pay day by cash, less 2½% discount, provided the Company have no claim on the Contractor as specified in Condition No. 13. In case of any dispute arising between the Contractor and the Company or their agents as to the meaning of any of the terms and conditions of this Contract, the decision of the Company's Engineer shall be final and binding upon all parties.

17. The Contractor shall, if required, enter into and sign a formal Contract with the Directors, and find good and sufficient surety to guarantee its proper fulfilment; the expense of such Contract and Bond to be paid by the Company.

18. The Directors do not bind themselves to accept the lowest or any Tender.

19. The Tenders are to be returned by post, addressed to "The Secretary, L., B. & S. C. R., London Bridge, S. E.," and must reach him not later than first post on .... endorsed on the outside cover "Tender for Sleepers."

Signed,

....

Storekeeper.

General Stores Office,
New Cross, S. E.

APPENDIX B.

NORTHERN RAILWAY COMPANY, FRANCE.

SPECIFICATIONS.—1893.

For furnishing beech ties of usual shape, creosoted by the new "Blythe" process, called Thermo-Carbolization.

Article 1.—The present specifications refer to the furnishing of ordinary ties for the extension and maintenance of tracks upon the Company's various lines.

Article 2.—The ties shall be of beech, creosoted by the new "Blythe" process (called Thermo-Carbolization).

Article 3.—The ties shall be rectangular, or present one of the sections shown in Figs. 1 and 2.

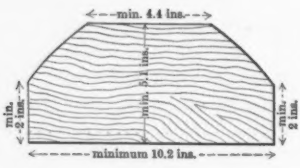

FIG. 1.

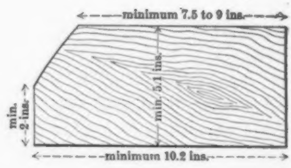

FIG. 2.

The top and bottom faces shall be sawed, the sides may be hewed.

The bottom face, which rests on the ballast, shall be square edged; the two lateral sides shall be without wane, for a minimum height of 2 ins. The top face shall be at least 4.4 ins. wide in the middle, and for the whole length of the tie.

The minimum dimensions of the ties shall be as follows:

Length (2.60 m.)...........................	8.53 ft.
Width (0.26 m.)...........................	10.2 ins.
Thickness (0.13 m.)........................	5.1 "

Article 4.—The ties shall be practically straight. If bowed sideways the incurvation shall not be more than $\frac{1}{20}$ of the whole length. All ties will be rejected whose bottom face is longitudinally bowed, being either convex or concave.

The ties shall be sawed off square at the ends.

Article 5.—The beech wood must be perfectly sound and of the best quality. It shall be neither heart-shaken, nor frost-split, nor

brashy, nor worm-eaten. It shall be exempt from doziness, rotten knots, cracks, splits, bad knots, red-heart or any other defect. The trees shall be felled between the 1st of November and the end of March. They shall be worked up into ties continuously, which work shall be completed by the end of April. Timber will be refused which has been felled before the 1st of November, or not worked up before May 1st.

All the ties shall be completely barked. As fast as the ties are made they must be piled up carefully, cob-fashion. The Chief Engineer of the Company reserves the right of putting on inspectors to follow up the felling and manufacture of the ties at various points.

Article 6.—The untreated ties will all be most carefully inspected, both as to quality and dimensions. Those accepted will be stamped at the ends with the Company's marking hammer.

All the sticks with any dimensions less than the limits stated in Article 3 will be rejected. Those with greater dimensions than required may be accepted, but no allowance will be made for oversize, the ties being purchased by the piece, and not by the cubic meter.

If a tie of good quality, and otherwise acceptable, shows a crack likely to spread open, the Contractor shall bolt the two parts together, or insert an **S** in the end, at his own expense. Every tie split open at the end for its whole width or thickness shall be rejected.

The rejected ties will be left on the hands of the Contractor at the point of inspection; they will be so marked as to preclude them from being again offered for inspection.

Article 7.—The untreated ties must be well seasoned before preparation, and, so far as possible, adzed and bored by the Company, to fit the rails and the lag screws. The seasoning will be tested by weighing a number of ties haphazard. The weight of the timber, thus ascertained, must not be more than 46.7 lbs. per cubic foot.

Article 8.—The ties will be injected with creosote by the new "Blythe" process, called "Thermo-Carbolization." In this process the ties are subjected to the two following operations:

1. They are enclosed in a cylinder of boiler plate and subjected to a current of steam mixed with creosote oil vapor for a length of time sufficient to insure, during the second operation, the absorption of the prescribed quantity of creosote.

2. The cylinder containing the ties is then filled with a sufficient quantity of crude creosote. This liquid, maintained at a temperature of at least 140° Fahr., is compressed in the cylinder by steam to five atmospheres from the generator, during a sufficient length of time so that the total quantity of creosote injected into the wood, both as a vapor and as a liquid, shall be at least 24.4 lbs.* per tie.

* Since increased to 35.2 lbs. per tie.

If the Engineer of the Company deems it advisable to increase this quantity of creosote, the Contractor will comply with the indications which he may receive relating thereto.

Article 9.—The creosote shall consist of the mixture of volatile products heavier than water distilled from coal-tar produced by gas-works. It shall contain at least 6% of carbolic acid, or of analogous products soluble in caustic soda. It shall be entirely soluble in benzine, and completely liquid at a temperature of 122° Fahrenheit. It must, moreover, conform to the samples which the Contractor shall submit to the Company's Engineer.

The Contractor shall specify from what gas-works each shipment of creosote is received.

Article 10.—The Company shall take cognizance of all the operations relative to the inspection of the wood, through an inspector appointed by the Chief Engineer. Such Inspector shall satisfy himself as to the thorough application of the "Blythe" process, shall keep accounts of the wood injected, and shall verify the results of the injection. He will report, upon a special blank, the following points for each operation:

1. The length of time of application of the mixed steam and oils coming from the vaporizer, as well as the final pressure in this operation, which must be at least five atmospheres.

2. The time occupied in filling the cylinder with crude creosote, the final pressure and the quantity of liquid absorbed during this operation.

3. The quantity of crude creosote introduced in the vaporizer and in the lower reservoir. This quantity shall not be less, for ten consecutive operations, than an average of 24.2 lbs. per tie injected.

4. Finally, the inspector shall keep an exact account of the total quantity of creosote which the Contractor shall receive at the works for injection, so as to check the amount of liquid absorbed during each season's work.

The Chief Engineer of the Company reserves, moreover, the right of using any other checks which he may deem desirable to control the quantity of creosote injected into the wood, either as a mixture of vapors or in the liquid state.

The royalties to be paid to Mr. Blythe or others for the use of the patents, etc., will be at the sole charge of the Contractor, who guarantees the Company against any claim of this nature.

All experiments made by the Company to ascertain whether the creosote is of good quality, and if the injection of the wood is complete, shall be at the charge of the Contractor.

Article 11.—Upon being withdrawn from the cylinder the ties shall be inspected one by one in order to ascertain whether the injection is homogeneous and whether the quantity of 24.2 lbs. has been duly

absorbed by each. This last verification shall be effected as described in Section 3 of Article 10.

Such ties as may be incompletely injected, a fact which shall be established by cutting into them with a gouging adze, shall be subjected to a second operation, or even to a third, after which they may be declared, in case of need, as unfit for injection, and finally rejected, as well as those ties which may be deformed by the action of heat in the cylinder.

The Contractor shall make no extra charge for these repeatings of treatment, and shall, moreover, either insert a bolt or an **S** into any tie which shall split during the treatment.

The ties accepted shall be counted and either immediately loaded on cars or piled up at some point designated by the Company's agent. The ties rejected shall receive a special mark at the rail seat and will be piled at special points to be indicated to the Contractor. These ties shall only be taken away upon authority given by the Engineer of the Company, who may hold them until the season's contract is filled, so as to avoid their being again presented for inspection by agents.

*Article 12.**—The final acceptance of the ties shall only take place six months after the full delivery of the season's contract.

Until this final acceptance the Company reserves the right of rejecting any ties which may possess defects not detected upon a first inspection, or which may split by reason of a bad quality of wood.

The ties so rejected will be surrendered to the Contractor at the point of delivery, who shall either deduct them from his bill or furnish other ties if required by the Company.

Article 13.—The Contractor shall be governed, save in such modifications as result from the present specifications, by the clauses and general conditions imposed upon contractors doing work for the Northern Railway Company, through the Rules drawn up September 26th, 1892, by the Chief Engineer of the Ponts et Chaussées, Chief Engineer of Maintenance of Way, approved October 21st, 1892, by the Executive Committee of said Company, and registered in Paris the 28th of the same month.

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* The same contractor furnishes the ties and treats them.

APPENDIX C.

IMPERIAL RAILWAYS OF ALSACE-LORRAINE, GERMANY.

SPECIFICATIONS FOR IMPREGNATING WOODEN RAILROAD TIES.—1898.

Section 1.—For pine ties, the impregnating fluid is a solution of chloride of zinc with an addition of coal-tar oil containing carbolic acid; for beech or oak ties hot coal-tar oil containing carbolic acid must be used.

Section 2.—The process of impregnating by chloride of zinc solution, with addition of coal-tar oil containing carbolic acid, is divided into three parts.

1. Steaming of the ties.
2. Production of a partial vacuum and admission of the impregnating fluid.
3. Compression (forcing in) of the impregnating fluid.

The ties are loaded on iron cars, which are pushed into the impregnating cylinder, this is closed air-tight, and they are exposed to the action of steam; steaming is continued for a longer or shorter period, according to the time of year and the condition of the ties. The admission of steam into the impregnating cylinder must be regulated in such manner, that an inside pressure of 1.5 atmospheres (22 lbs. per square inch) above air pressure is reached within 30 minutes. For dry ties it will suffice to maintain this pressure in the impregnating cylinder for 30 minutes longer, but for green ties it should be kept up for another hour. For dry ties, therefore, the steaming takes at least 1 hour, while for green ties at least 1½ hours are necessary. A gauge attached to the cylinder indicates existence of the specified pressure. The valve at the bottom of the cylinder must be opened on admitting the steam, in order that the air contained in it may be driven out, but should be closed when steam begins to blow out. This valve should be opened repeatedly, as fast as steam condenses; open it at least every half-hour to draw off the water, and for the last time just before exhausting the air. When steaming is finished, the steam remaining in the impregnating cylinder is allowed to escape.

After steam is discharged a partial vacuum is produced in the cylinder containing the ties, until the vacuum gauge shows at the least a column of mercury of 60 cm. (23.6 ins.); this partial vacuum

must be maintained for ten minutes. On expiration of this time, while continually preserving the partial vacuum, allow the impregnating fluid, which meanwhile has been prepared in a separate vessel and heated to at least 65° Cent. (149° Fahr.), to enter the impregnating cylinder, filling it entirely. To prepare the impregnating fluid, add while heating, 1 kgr. of coal-tar oil to every 15 kgr. ($6\frac{2}{3}$%) of the solution of zinc chloride.

To insure as perfect a mixture of the solution of zinc chloride with the coal-tar oil as possible, an effective stirring apparatus, combined with injection of steam and air, must be applied.

Next, a pressure pump is used to exert an excess of seven atmospheres above air pressure. This pressure to be maintained for not less than 30 minutes; if necessary, continue it for a longer time, until the ties have absorbed a certain amount of impregnating fluid as specified hereafter. The impregnating fluid is then run off.

The chloride of zinc solution intended for impregnating must be as nearly as possible free from foreign substances, and there must be no free acid. An admixture of other metals, notably iron, can only be allowed in a very slight percentage and only if it cannot be avoided in the manufacture. The solution must have a strength of 3.5° Beaumé = 1.0244 specific gravity at a temperature of 15° Cent. (59° Fahr.). The solution contains 1.26% of metallic zinc.

The coal-tar oil used must not contain over 1% of oils that boil below 125° Cent. (257° Fahr.). It must be so little volatile that its boiling point lies mainly between 150° and 400° Cent. (302° and 752° Fahr.). In no case is it permissible to have more than 25% of its weight volatilized below 235° Cent. (455° Fahr.). It must contain at least 20 to 25% of acid substances (creosote or oils resembling carbolic acid) that are soluble in caustic lye of soda of 1.15 specific gravity. The coal-tar oil must be entirely liquid at + 15° Cent. (59° Fahr.), and as much as possible free from naphthaline, so that on evaporation (fractional distillation) produced in a glass vessel in groups of 50° each, it shall leave a residue of not more than 5% of naphthaline. Its specific gravity should not be less than 1.020 at a temperature of + 15° Cent. (59° Fahr.) and should not exceed 1.055. To remove such impurities from the impregnating fluid as are due to the process, suitable settling (clarifying) apparatus should be provided.

The Contractor is required to report where he obtains his supplies of zinc-chloride solution and of coal-tar oil, intended for use, and to furnish samples of the same to the Supply Office of the Imperial Railways at Strassburg in Alsace before commencing to impregnate. He will be permitted to purchase the solution of zinc chloride and the carbolized oil of coal-tar only from such factories whose samples have been approved by the Management of the Railways. The Railway Management reserves the right to test the fluids used at any time.

It is specified that the average absorption of impregnating fluid contained in every charge of the cylinder shall be the following:

A. Absorption of 35 kgr. (77 lbs.) for each tie of the first class, length of 2.70 m. (8.85 ft.).

B. Absorption of 26 kgr. (57 lbs.) for each tie of the second class, length of 2.50 m. (8.2 ft.).

C. Absorption of 310 kgr. per cubic meter (19 lbs. per cubic foot*) for ties of other dimensions.

To determine the amount of impregnating fluid absorbed by the ties, the following method must be adopted:

Weigh all ties on a platform scale placed under roof immediately before steaming them, and again after impregnating when dripping has ceased. The difference in weights equals amount of impregnating fluid absorbed. A deduction of 15 pfennigs per 10 kgr. (16 cents per 100 lbs.) will be made for shortage shown by this weighing test. In case the shortage amounts to more than one-sixth of the absorption specified, the impregnation must be repeated. If, on the other hand, the weighing shows that the ties have absorbed more than the amount specified, a bonus of 15 pfennigs for every 10 kgr. (16 cents per 100 lbs.) will be paid for such increase, up to a maximum of 15 per cent.

Section 3.—The work of impregnating with hot carbolized oil of coal-tar (*i. e.*, oil of coal-tar containing carbolic acid) must be divided into two parts.

1. Drying of the ties, *i. e.*, withdrawing water from them.
2. Introduction of oil of coal-tar under pressure.

The ties are run into the impregnating cylinder and this is closed air-tight. Next, a partial vacuum, equal to at least 60 cm. (23.6 ins.) column of mercury, is produced in the impregnating cylinder and maintained for 10 minutes, and thereupon, while keeping up the vacuum, the hot oil of coal-tar is made to flow in until it rises to a level that will prevent sucking over by the air pumps. The flowing in of the coal-tar oil may be accomplished all at once or at intervals, according to the dryness of the ties. While thus filling up, and afterward, the coal-tar is heated up inside the cylinder to at least 105° Cent. (221° Fahr.), but not higher than 115° Cent. (239° Fahr.), by means of steam coils. This heating should be accomplished during a space of time of not less than 3 hours. When this temperature is reached in the impregnating cylinder, it must be kept up for another hour, either with or without the partial vacuum, as may be judged necessary, in order that the ties may absorb the specified amount of oil of coal-tar.

The impregnating cylinder is connected with a pipe condenser from the instant that filling with hot coal-tar oil commences, and all the

*3.5° *B.* corresponds to 2.62% dry zinc chloride. Hence, $19 \times 2.62\%$ amounts to 0.498 lb. of dry zinc chloride per cubic foot.—O. C.

aqueous vapors driven out of the ties are condensed in this, the water being carried to a tank. This receiver must have a water gauge from which one can read off the amount of water evaporated from the ties.

After the drying of the ties or the extraction of water from them is finished, the impregnating cylinder is filled completely and the pressure pump started, which must produce a pressure of at least 7 atmospheres. This pressure is to be maintained for at least 30 minutes in treating beech ties and 60 minutes for oak ties, unless it proves necessary to prolong the time to obtain the amount of absorption specified. The oil of coal-tar is then drawn off.

The coal-tar oil used must be heavy oil, derived from the distillation of coal-tar, of greenish black color, specific gravity of 1.045 to 1.100 at 15° Cent. (59° Fahr.), boiling point between 150° and 400° Cent. (302° and 752° Fahr.).

While making fractional distillation no oils must pass over below 150° Cent. (302° Fahr.) and not more than 25% of the volume at temperature up to 235° Cent. (455° Fahr.).

The coal-tar oil must contain by volume at least 10% of carbolic acid and, at a temperature of 15° Cent. (59° Fahr.), must be free from naphthalene and show no sediment.

To determine percentage of carbolic acid apply agitation to the oils heated to 400° Cent. (752° Fahr.) with a caustic solution of soda having specific gravity of 1.15. The difference in volume of oil before and after agitation gives percentage of carbolic acid.

The Contractor is required to state source of supply for his coal-tar oil and to furnish samples to the Supply Office of the Imperial Railways at Strassburg before he commences work of impregnation. The coal-tar oil can only be purchased from factories whose samples have been approved by the Railway Management. The Railway Management reserves the privilege of at any time testing the coal-tar oil used.

It is specified that the average absorption of coal-tar oil for every charge of the cylinder shall be:

a. For one railroad tie, 1st class, 2.70 m. (8.85 ft.) long, of oak wood, 11 kgr. (24 lbs.); of beech wood, 36 kgr. (79 lbs.).

b. For one railroad tie, 2d class, 2.50 m. (8.20 ft.) long, of oak wood, 8 kgr. (18.6 lbs.); of beech wood, 28 kgr. (61.6 lbs.).

c. For ties of other dimensions per cubic meter (35.3 cu. ft.), of oak wood, 100 kgr. (220 lbs.); of beech wood, 325 kgr. (715 lbs.).

To determine the amount of coal-tar oil absorbed by the ties, these are weighed before the impregnation and again after it, when dripping of oil has ceased, using a platform scale placed under a roof. The difference in weight is amount of coal-tar oil absorbed. Correct the weight of the ties before impregnation by deducting from it weight of water delivered by condenser to the tank and obtained from the vapors distilled while drying in hot coal-tar oil, as weight of ties is reduced

to this extent by drying process. If on examination it is proved that absorption amounts to less than five-sixths of that specified, the impregnation must be repeated.

For every shortage in coal-tar oil shown by above test, a deduction of 50 pfennigs for 10 kgr. (54.5 cents per 100 lbs.) will be made, but, on the other hand, an increase in absorption will be paid for at the same rate, a maximum of 15% increase being the limit of such payment.

Section 4.—The Contractor is required to give eight days' notice to the Supply Office of the time of intended commencing to impregnate ties, in order that the office may send an official to supervise same. This official must be freely admitted at all times to the plant of the Contractor, and all desired information must be readily furnished him. The Contractor must furnish all necessary appliances, apparatus and labor to make tests without charge.

Section 5.—In case the Contractor does not supply his own ties, the parties furnishing them will be required to deliver f. o. b. cars at the station nearest to the impregnating works, provided they are shipped by rail; ties delivered by wagon or other conveyance will be delivered loaded at storage yards of the factory without charge.

The hauling of ties from the station to factory will be at the expense of the Contractor for impregnation. He has also to provide for unloading, piling and handling of ties as per regulations. The Contractor will be paid for this labor the amount of 8 pfennigs (1.92 cents) for each track tie and 4 pfennigs (0.96 cent) for each switch tie of 1 m. These prices cover the expense of labor and tools required in receiving green ties, as well as that of reloading rejected ties; payment for a tie to be made only once.

Section 6.—The Contractor for impregnating is held liable for all damages and loss of ties that may occur from the time they are delivered to him at the railroad station, or at his works, as long as ties remain at his works. This liability includes losses by fire occurring at the impregnation works and by theft committed while ties remain there. The Contractor must pay the value of all missing ties or of such as become unserviceable previous to their return after impregnation, but is not liable for splitting. He is, however, required to furnish without charge all necessary S-hooks and bolts for drawing together the cracks occurring during storage, and has to drive or put these in according to directions of the supervising official.

When ties are turned over to the Contractor for impregnation, they are already supplied with S-hooks needed to draw together all existing cracks. Each beech track tie is also fitted with two iron bolts running through it, about 10 cm. (4 ins.), from each end in the direction of its breadth. It is his duty, therefore, to supply, without charge, only such S-hooks and bolts as may be needed thereafter, and of the same kind, and to fasten them.

Section 7.—On receiving the green ties they must be piled at the factory in such a way that air will circulate freely around each one. Each pile only to have length and breadth equal to length of one tie, and must contain 100 ties. The lowest layer of ties must rest on solid supports, so that they will never touch the ground. Storage yards must be thoroughly drained and have ditches if needed. Open spaces are to be left between the piles, which spaces must measure 80 cm. (32 ins.) in one direction and have a width of 40 cm. (16 ins.). This piling of ties must be finished at the latest in 14 days from receipt of same. Date of piling to be plainly marked on each pile.

For delay in completing impregnation of ties beyond time fixed by contract, unless previous express and written permission of the Imperial General Management has been obtained, the latter will collect a penalty from Contractor for such delay, amounting to 1% of the Contract value of the unfinished impregnation per week of such delay.

Section 9.—The Railroad Management reserves the right to employ the Contractor for impregnation to adze surface of ties in places for bed-plates of rails, as well as to bore holes for fastenings, if such work becomes necessary. This work to be done by direction of supervising official and before impregnating.

Strassburg, February....1898.

Imperial General Management of
Railways in Alsace-Lorraine.

Acknowledged: The preceding contract of......................
this day the............... 1......

D.........................
Contractor.

APPENDIX D.

TESTING OF IMPREGNATING SOLUTIONS FOR IMPERIAL PRUSSIAN RAILWAYS.

For the impregnation of timber there are at present two products in use: 1st, chloride of zinc; 2d, tar-oil.

Testing of Chloride of Zinc.

The chloride of zinc for impregnating purposes will be manufactured as a concentrated solution, containing about 50% of anhydrous chloride of zinc. It is best to use such a strong solution for testing, and for that purpose, samples are to be taken directly from the shipping tank or carboy.

The zinc chloride solution used must be as free from impurities as possible, particularly from iron and free acid. Therefore, it is to be determined whether or not iron and acid are present.

Test for Free Acid.

Twenty grammes (by weight) of the above strong zinc chloride solution are to be mixed with distilled water; the whole to amount to 100 cu. cm. (by measure), the mixture to be well shaken.

a.—There is no free acid present if the mixture, by shaking, becomes cloudy, and, particularly if after a short period of rest, flakes settle down, which will again dissolve to a clear fluid, upon the addition of a few drops of muriatic acid (H Cl). No further test is then required.

b.—If, after shaking, the mixture remains clear, then an excess of acid is present, the amount of which can be determined by the following manipulation:

Take several reagent bottles and put in each 10 cu. cm. of the above-described mixture, then add to each bottle a measured successively increasing quantity of a solution of one-tenth normal soda. For example: Add to the first reagent bottle 0.1 cu. cm., to the second 0.2 cu. cm., to the third 0.4 cu. cm., and so on. Shake well and observe in which bottle a remaining white flaky precipitation will settle. The proportion of soda which lies between the mixture where a precipitation is produced, and that where no precipitation is produced, exactly represents the quantity of free acid present in the solution. For example, the mixture in the bottle to which 0.2 cu. cm. of the soda solution was added, remains clear, while in the following reagent bottle, where 0.4 cu. cm. soda solution was added, a precipitation is produced; then, 0.3 cu. cm. soda solution is exactly the quantity corresponding to the free acid present in the chloride of zinc solution.

Should there be required for this test more than 0.4 cu. cm. of the one-tenth normal soda solution, then the percentage of free acid is too high in the chloride of zinc solution, and such solution must not be used for impregnation.

Testing for Iron.

Take 10 cu. cm. from the above-described mixture of zinc chloride solution and distilled water, and add a few drops of concentrated nitric acid ($H\ N\ O_3$) and shake well. Divide this mixture into two equal parts. To one part, without diluting, add a quantity of ammonia ($N\ H_4\ O\ H$) and shake well. If this mixture remains clear, no iron is present. Through the presence of iron in the mixture, more or less brown flakes will precipitate, corresponding to the amount of iron present. Should there precipitate in the mixture a quantity of gray-white (not brown) flakes, then not only iron, but also another impurity (nearly always magnesia) is present. In this latter case a more complete test has to be made, and, therefore, the zinc chloride solution must be sent to a chemist. But this case will happen very seldom.

The second part of the mixture of 10 cu. cm. to which nitric acid was added, should be diluted with distilled water, and 5 cu. cm. of a solution of 10% yellow prussiate of potash added, the whole to be well shaken. A very ample precipitation will be produced, which will look snow-white, or very light yellowish, if the zinc chloride solution is free from iron; but in the presence of iron it will look more or less blue, according to the amount of iron. If the precipitation shows a corn flower blue color, then the zinc chloride solution surely contains a high percentage of iron and must therefore be rejected.

To avoid, in testing, the weighing of the 20 grammes of the strong solution, the use is recommended of the easier method of measuring. First find the specific gravity, at 15° Celsius, of the strong concentrated zinc chloride solution. The quotient of this specific gravity into 20 grammes shows the number of cubic centimeters which must be measured off and which represent exactly 20 grammes by weight. For instance, the specific gravity of the strong zinc chloride solution is 1.6, then 1.6 divided into 20 grammes gives the number of cubic centimeters $\left(\frac{20}{1.6} = 12.5 \text{ cu. cm.}\right)$ which have to be measured off to be used for testing as described before.

Testing of Tar-Oil.

At a temperature of 20° Celsius the tar-oil must be limpid, and to test it, shake the tar-oil well, pour a few drops on a folded filter paper, and observe whether after absorption there remain undissolved particles on top of the paper. If the amount of these is large, the tar oil must not be used for impregnation. To find the specific gravity, the

tar-oil must be heated, or cooled off, to a temperature of 15° Celsius; then drop slowly an hydrometer into the same, and read the number at the surface of the oil. This number indicates the specific gravity of the tar-oil at 15° Celsius; small variations in temperature are of minor importance, and can be corrected closely enough by adding or subtracting 3 to the figure in the third place of the specific gravity for every 2° variation from 15° Celsius.

Laboratory Distillation of the Tar-Oil.

By means of a funnel, 102 cu. cm. of tar-oil at about 15° Celsius are to be filled into a retort, a thermometer is to be inserted, but in such a manner that the quicksilver ball shall be in or below the neck of the retort but shall not touch the oil, or will not be covered by the same. The retort must be heated slowly, until all the water, which is contained in nearly every tar-oil, is evaporated. Stronger heat can then be applied to the retort, but it must be so regulated that in one second two drops will distill over. The distilled product will be caught in a graduated glass cylinder, and the different quantities are to be read and noted which distill over from the oil (become volatile), within the various intervals of temperature, say to 125° Celsius (150°) from 150° to 235°, and again from 150° to 355° Celsius, and which are specified in the "Description of the Process, and Specifications" as to the composition and proportions of the impregnating fluid.

Finding the Percentage of Carbolic Acid.

(Acid Constituents of the Oil.)

The entire amount of the distilled tar-oil is to be mixed in a separating funnel with 50 cu. cm. of caustic soda of 1.15 specific gravity at 15° Celsius, shaken well for about five minutes, after which let it stand and settle. The caustic soda absorbs the carbolic acid and precipitates; the stopcock of the funnel is to be opened and the precipated caustic soda is caught in a 200-cu. cm. graduated glass cylinder. The same operation must also be repeated with 50 cu. cm. of fresh caustic soda, to make sure that all carbolic acid is extracted from the oil. The caustic soda of both manipulations is then to be combined, about two tablespoonfuls of salt ($Na\,Cl$) added and this dissolved by means of stirring; the required quantity of concentrated muriatic acid ($H\,Cl$) added, and the combination again stirred up until well mixed. After cooling off the hot mixture, read the quantity of the separated carbolic acid in percentage of cubic centimeters, and add to this number ½% for the small amount of carbolic acid still remaining in the acid solution.

All the figures obtained are to be compared with those specified in the description of the composition and proportions of the impregnat-

ing fluids. Small differences should not be cause for rejection, as small variations in testing, resulting from barometric changes, cannot be avoided, and the result of the test is influenced by them. However, the figures obtained by the above-described tests are sufficiently close to judge of the quality of the impregnating fluids. It is not advisable that the tar-oil for testing be taken directly from the shipping tank, but it is better to take the samples from the receptacle of the apparatus in the impregnating plant from which the mixing vessels, or the impregnating cylinder (in the impregnation with pure oil) will be supplied.

The Chief of the Operating Inspection 3.

(Signed.) SETTGAST.

BERLIN, June 14th, 1899.

DISCUSSION.

Mr. Croes. J. JAMES R. CROES, M. Am. Soc. C. E.—This interesting paper contains many valuable facts and figures, but the variety of notation used in presenting them renders it somewhat difficult to compare the results attained in different countries and by different processes of preservation. Thus, in Table No. 1, which gives data from English railroads, the amount of creosote used is given in pounds per cubic foot, gallons per cubic foot, pounds per tie and gallons per tie, indiscriminately, without any statement as to the relation of the tie, the cubic foot, the pound and the gallon. Then, too, the number of ties renewed annually is given without any reference to the total number of ties in use or the length of the track, except in one case where the number of ties renewed annually per mile is given. So, also, in Table No. 2, giving data of French railroads, the length of track on which the observations were made is not given at all; simply the total number of ties renewed annually. However, the cost of treatment per tie is given uniformly in American cents per tie and that is, after all, what it is necessary to know, in connection with the life of the tie, to determine the relative advantage of using different methods of treatment or no treatment at all. As the author well says, it is not economical to spend as much money on the preservation of a cheap tie as might be spent in extending the life of one of great first cost, and, therefore, cheaper and more inferior methods of preservation than are found advantageous in Europe, where the timber costs more, may well be applied in this country.

The author gives as the first two of the leading features of tie treatment in Europe, (1) close inspection of raw ties, rejecting all defects, and (2) thorough seasoning for six to twelve months before treatment. It appears that he has found it desirable to introduce these features in his own works in this country. A number of railroad managers and engineers have found it to their advantage to take the same precaution with reference to the ties to be used in their roads, without treatment. Indeed, some engineers go so far as to say that this preliminary treatment appears to prolong the life of the average tie more than the subsequent injection of a small quantity of cheap chemicals. It would seem as if this question was worth a careful investigation and a comparison of two distinct sections of road, one laid entirely with untreated ties selected and seasoned under cover for a proper length of time, and the other laid with treated ties from some one of the commercial tie plants. One difficulty connected with the determination of the whole question is, as the author says, the fact that it requires nearly half a business lifetime to arrive at any results, and the proportion of an official lifetime is much greater. In carrying

out any series of experiments or inspection, uniformity of method is desirable, and that is not easily maintained under changes of administration. From the Society lists for the years 1890 and 1900 it appears that of one hundred members holding the position of chief engineer of a railroad in the former year only 30% held the same position in 1900. Promotion, transfer, resignation or death, had caused the changes of administration, and, in the absence of any uniform and standard system of recording facts and statistics, had doubtless produced changes of method which caused previously collected data to be of little or no use. The valuable papers of Mr. Chanute and Mr. Curtis* emphasize the need of a concert of action among the engineers of railroad maintenance, in the collection and recording of important statistics. Mr. Croes.

W. B. Reed, Assoc. M. Am. Soc. C. E.—There are a few vulcanized ties on the Metropolitan Railway, and, as nearly as the speaker can ascertain, these were laid about eight years ago. In taking out some of them recently, they were found to be so soft that they would not hold a spike. They did not seem to be decayed, but had evidently absorbed more or less moisture from the ground, and were not fit to be used again. On the other hand, some long-leaf Georgia pine or southern pine ties, without any treatment, which had been laid by the speaker six years or seven years ago, are perfectly fit to be used again, and are thought to be good for five or six years' more service. Of course, the conditions are different from what they would be on a steam railroad, or on an elevated railroad. The ties are protected, more or less, by the paving of the streets, and are surrounded by the gases of various kinds under the street pavements of New York. Whether or not that is a preservative, the speaker is unable to say. Mr. Reed.

Eight or nine years ago, the speaker used 5 000 vulcanized ties in a surface railroad in the northern part of New York State. Five or six years later, owing to a change in the paving, some of these ties were dug up and were found to be so soft that they would not hold a spike, although they did not show much decay.

These ties were of short-leaf yellow pine, which may be one cause for the trouble. The wood was certainly softer in the beginning than the hard pine now being used in the streets of New York where tie construction is used.

The speaker is not able to say whether or not these soft ties would have hardened when dried out by exposure to the air. He did not try them, as he did not think they were worth saving. The whole tie was very soft, and there was not a great deal of moisture. The ties referred to were taken out at the intersection of Twenty-third Street and Ninth Avenue, where the ground is not low, but is fairly well drained, although the paving at that point had no concrete foundation, and more or less moisture could get through the pavement into

* *Transactions*, Am. Soc. C. E., Vol. xlii, p. 288.

Mr. Reed. the ground. The other ties taken out (long-leaf southern pine, not treated) were on South Street. They were protected more or less by a concrete foundation under a granite block pavement, with tar and gravel joints, but South Street is very wet a great deal of the time; in fact, it is flooded with water for a long time after a storm, so that the ground underneath is a good deal more moist than at Twenty-third Street and Ninth Avenue.

Mr. Tillson. G. W. TILLSON, M. Am. Soc. C. E.—The speaker was interested some time ago in looking up the methods and history of the preservation of timber, to see how long ago it was first taken up, and the many and curious experiments which were made. It is known that as far back as 1657 a German recommended the use of tar as a preservative of timber, and Baumeister, in 1798, was very much in favor of the use of salt. It was found that the timber used in ships engaged in the salt-carrying trade, as well as that used in the shoring up of salt mines, lasted a much longer time than timber under ordinary conditions, and the speaker was surprised this last summer, when visiting the wooden shipbuilding section of Maine, to find that they made use of that practice there now. The salt is distributed in great quantity among the timbers in the framework of the vessel, between the outer and the inner planking, and adds materially to the life of the vessel. This value of the salt is considered more on account of its hygroscopic than its antiseptic properties.

Boucherie, of whom the author speaks, had a system of treatment in the early part of the nineteenth century, which was certainly novel and unique. The timber to be treated was chosen while standing in the forest. Large cuts were made at the bottom of the trunk and a receptacle built around it; then the liquid proposed to be used was put in this receptacle and the respirative action of the tree—the suction—drew the liquid up into the trunk and branches and thus preserved it. Another method, practically the same, although somewhat different in detail, was to cut the tree down first and then insert the butt of the tree in a vat containing the preserving liquid. It is stated in Parnell's Applied Chemistry that a poplar tree 90 ft. high absorbed 10 cu. ft. of acetate of iron in six days, the liquid having a specific gravity of 1.056, and that it would go up as far as the leaves. If engineering is admitted to be the adaptation of the powers of Nature to the uses of man, this would seem to be a case of the pure science.

In Mr. Kummer's paper* some reference is made to the treatment of wood for pavements. The speaker thinks that Indianapolis, Ind., is the only city in this country in which wood as a paving material for an improved pavement is being considered seriously. Experiments

* "A Proposed Method for the Preservation of Timber," *Transactions*, Am. Soc. C. E., Vol. xliv, p. 181.

have been conducted there for three or four years, and this year a large quantity of it has been laid. The timber is treated by the ordinary creosoting process, the specifications requiring 10 lbs. of oil per cubic foot of wood. The pavements treated by this method cost about $2.50 per yard. In London and other English cities which use wood as a pavement, soft wood, Baltic deal, is treated, while hard or Australian woods are untreated. Of course, the principle by which they determine whether they shall or shall not creosote the wood is practically the same as with railroad ties. If the traffic is such that the wood will wear out before it would naturally decay, it is not treated; but if the traffic is light, so that the wear will not be very much, but the life of the pavement be determined by its ability to resist the action of the weather, then the question of creosoting comes in, and when the relative lives of the creosoted and the uncreosoted blocks are known, and also the cost of the treatment, whether it shall or shall not be used is simply a question of mathematics, as in the case of ties. Mr. Tillson.

MENDES COHEN, Past-President, Am. Soc. C. E.—When this subject was under discussion before the Society some years ago, the speaker stated as the result of his experience with the Burnettizing process on the railways of the Lehigh Coal and Navigation Company, while under his charge, that the process was effective, not only in increasing the durability of the ordinary tie timber, but that, in a measure, it tended to lessen the original average cost of the ties by making available for such use some of the softer timber, greatly toughened by the treatment, which could not, otherwise, have been used in the track. Mr. Cohen.

He also then stated that the use of the Burnettizing process was suspended on that work only because the location and arrangement of the yard and plant was not consistent with economical handling. Before its re-location was effected, the railway property passed into the control of another corporation, and the speaker had no further information in regard to it.

SAMUEL WHINERY, M. Am. Soc. C. E.—From the speaker's observation in a number of cases, he thinks that a great deal more importance attaches to the proper selection of the wood to be treated than has often been devoted to the matter. In some of the work which he has observed, the timber was cut without much reference to whether it was long-leaf yellow pine or scrub pine. It was brought to the works in all conditions of seasoning, and he has no doubt, from the observations made since, as well as from what Mr. Chanute states in the paper, that the careful selection of the timber and its proper preparation by seasoning before it is treated has much to do with the success of the process. In the case of paving blocks, there can be no question that properly selected wooden blocks, properly creosoted, will give much better results in all cases where untreated blocks would fail Mr. Whinery.

Mr. Whinery. by natural decay before they are worn out by the travel over them; but it is very doubtful whether creosoting adds anything to the ability of the blocks to withstand the abrasion of travel.

From what one often sees in practice, it would seem that anything is considered good enough to creosote. That is, that almost any kind of wood, even if partly decayed, is all right if creosoted. The idea that creosoting is a cure for all the evils that wood is heir to is undoubtedly wrong. If great care were taken to properly select the timber, and to properly prepare it for the process, there would be fewer records of failure.

Those who have had experience in using yellow pine ties on southern railroads know very well that, in the first place, there are not many inspectors who can distinguish, when a tie is dressed and delivered on the road, whether it is of long-leaf yellow pine or bastard pine, that is, in appearance one merges so gradually into the other that it is sometimes difficult to decide. We know very well, though, that of a lot of ties put into a track at a given time, some will begin to fail in 4 years, more in 5 and many more in 6 years, and that some will last 10 years, and a few will last even 11 and 12 years. The conditions of use being practically the same, the difference in durability must be due to a variation in the quality of the timber.

Mr. Rowe. SAMUEL M. ROWE, M. Am. Soc. C. E. (by letter).—Mr. Chanute's paper, embodying, as it does, a fair epitome of European experience and knowledge up to the present time, is of much interest to those concerned in timber preservation in this country, and seems to deserve more than a passing notice.

The following is a synopsis of the salient points to which the writer will revert, and, for the sake of brevity, and to avoid the necessity of referring directly to the subject in each individual case, he will take them up in the order given:

(*a*) Greater cost of creosoting than of Burnettizing.
(*b*) Life of treated ties in Europe as compared with this country.
(*c*) Selection of timber.
(*d*) Drainage of road bed.
(*e*) Thorough permeation of the timber by the preservative.
(*f*) Increasing the amount of chemicals injected.
(*g*) Minute care during all stages of treatment. (Impregnation.)
(*h*) Treatment of oak. (White oak.)
(*i*) Test of strength and purity of chemicals.
(*j*) Timber supply.

(*a*) In regard to the creosote process, Mr. Chanute's observations in Europe seem to confirm the correctness of the position taken by the writer and many others in this country, that, owing to the difficulty of procuring suitable oil, and from its large and continually increasing

cost, the process is virtually ruled out in this country, except, perhaps, in special work required to protect timber against the teredo. Mr. Rowe.

This is also true, in some degree, with the zinc-creosote process by Mr. Rutgers, of which process Mr. Chanute seems to think very highly.

(*b*) In regard to the life of treated ties in this country, the experience on the Atchison, Topeka and Santa Fé R. R. and the Southern Pacific R. R., after 12 to 15 years, seems to fix the mean at 10 to 12 years, where the zinc-tannin process was used.

In this connection, the writer's experience may be of value. The original mountain pine ties were laid on a portion of the Southern Division of the A. T. & S. F. R. R. in 1880, and by 1886 the right of way was strewn with removed ties, or rather, with masses of rotten wood, having but little semblance to the ties originally laid. There was then a standing order that removed ties should be piled and shipped to the division points for locomotive fuel. Finally, the accumulation became so great and its unfitness for fuel so obvious, that many huge bonfires were the result. From this experience with untreated pine ties, a life of 4½ years was all that could be deduced. Some of these ties failed in the third year, and the company was face to face with a serious problem. In July, 1885, the Las Vegas Timber Treating Works were installed, and have been in almost constant operation since, but no systematic count of treated ties removed was made until early in 1897, since which time the company has worked quite carefully to secure a record. Although this record is too limited as yet for definite estimate, it furnishes a basis for a statement (by the laws of averages) by which the probable mean life can be estimated. On the assumption that the mean life is 12 years, it is found that of the earlier treated ties, not anything like the numbers that should have perished have been removed, so that it is proper to assume that 12 years is too low. The writer is informed that very many ties laid in 1885 are still in the track, and he would not be surprised to find some still in at the end of the twentieth year. To settle this definitely, however, will require the record of the next 3 or 4 years. We have, nevertheless, sufficient to show the marked contrast between the untreated and the treated ties, and there are frequent acknowledgments from the management that the substitution of the treated ties has resulted in marked economy. It should be further remarked, that the condition of the track is now very much better than was possible when untreated ties were being used, and that the treated ties, when removed, are in much better condition than the untreated, having still considerable sound timber remaining, whereas the untreated ties when removed are entirely gone.

There is no parallel by which to compare the results with those in Europe, except one case of pine in France, and in the case of Mr.

Mr. Rowe. Rutger's zinc-creosote, where the result as to life is somewhat better than is given here with the zinc-tannin process.

(c) The advisability of drawing high requirements as to the quality of the timber in this country is not clear, except merely for comparison with work in Europe where the specifications are severe, which is here of little consequence practically. The fact is, that the tie supply in this country has been and will continue to be drawn from inferior woods; and even with the oaks, only the inferior portion is being made into ties, while the select portions go to other purposes. This is true as to other and less durable timbers, not heretofore considered fit for ties; hence the railroads will continue to buy the cheaper grades. It is in consequence of these conditions that the soft and inferior woods, by the aid of treatment by which their lasting qualities are made greater than those of the best oak, will be sought. Thus is opened a much enlarged field of supply, together with a reduction in cost and a very marked reduction in the cost of maintenance.

Another point which may properly be noticed is the sawing of ties from large logs, which should make good ties on account of the superiority of the timber and its lasting qualities compared with the sap-pole tie made from the same kind of timber. The timber should last one-half longer at least, other conditions being equal. The practice now common is to cut the ties 6 x 8 ins., and 8 ft. long, containing $2\frac{2}{3}$ cu. ft., while the mean volume of the pole tie, upon which the number and distribution of ties under the rail has been founded in railroad practice, is more than 4 cu. ft. These sawed ties are so small that they do not form a sufficient support for the rail, unless the number is materially increased; and they are apt to fail, from rail wear or from insufficient body to hold the spikes, long before the timber decays. It would seem that a tie 7 x 9 ins., with a volume of $3\frac{1}{2}$ cu. ft., would be as small as should be made. Such a tie, properly treated, would last 15 years or more.

In connection with English timber preservation, Mr. Chanute mentions "Baltic redwood." In discussing these questions it would be well to state, for each kind of wood, the characteristics by which it might be judged. These characteristics have much to do with the lasting qualities, and, if some standard could be devised, for instance, the oak, heavy, close-grained, strong and lasting, the beech, walnut, etc., close, even grain, but not so strong or lasting, and lastly, the pines, etc., so as to enable those interested to judge somewhat as to their character, it would be a great aid in comparing results. Mountain pine, to which western railroads are obliged to resort, runs largely to open-grained timber, easily penetrated and taking the treatment readily if dry, yet it is an inferior timber, with many imperfections. Of course, some portions of the large, well-grown trees give sound, compact, well-matured fiber, and therefore,

should be quite lasting, but taking all together, the timber treated in Europe, high priced, cut and shipped under severe specifications, forms hardly a fair parallel. The very fact that these A. T. & S. F. R. R. ties have been made to last 12 years, or anything like it, speaks well for the efficiency of the treatment and methods followed at Las Vegas. Mr. Rowe.

(*d*) Mr. Chanute mentions, as one of the conditions favorable to the life of the tie, the thorough drainage of the road-bed.

In this country, in almost all cases, the treated ties are shipped directly from the works to the locality where needed, and are there racked, ready to be put in place. In the interval, they receive a certain, or rather, an uncertain, amount of drying, and are then put in track. In a dry climate this is not so important, but in a moist climate it is conceded that the ties should be quite dry before being placed. Taking this condition as requisite, the effect on the tie of exposure to the elements will be considered. The generally accepted theory of the capillary process of absorption of water when the wood comes in contact with it, is probably correct. The chloride in the treated tie, being readily soluble, is dissolved by the water, and carried with it as it penetrates the piece. By the contrary operation of surface evaporation in drying out, the chloride will be gradually dropped, and finally, such of it as reaches the surface of the wood, will be deposited on its surface, or in the soil in which the tie is bedded and there be lost. It is easy to see that this may result in loss and final wasting away of the antiseptic to a greater or less degree, depending upon the frequency of the exposure. Then, when drainage is imperfect and the tie lies in the water all the time, the absorption being continually from the bottom and the evaporation from the top, it is easy to see that the waste must be more rapid than when it is alternated, as by showers of rain.

In confirmation of this general theory, the Department of Agriculture has made some careful investigations on alkali soils, by which it is found that alkali sinks into the soil on free application of irrigating water, allowing cultivation of the soil, but when the irrigation ceases and the ground is exposed to extended drought, the alkali again rises and the land becomes sterile as before.

The alkali (sodium sulphate) existing in the soils and ground-waters of the western plains has the same characteristics as chloride of zinc, being only a little more readily soluble, and increases the specific gravity of the water. At Edgemont, S. Dak., the water used has nearly 125 grains of sodium sulphate per gallon, giving, at 60° Fahr., a hydrometric reading of 0.25° Beaumé, so that this correction has to be made in reading the strength of the chloride solution.

It would seem, too, that the effect of water on creosoted timber, while not so deleterious as on the chloride (as it only affects the lighter

Mr. Rowe. and less valuable parts of the oil), is still sufficient to demand attention. Creosote not being at all soluble, a different cause for its expulsion must be sought. It is well known that wood expands when exposed to dampness, the wood fiber absorbing the water and opening up, while the wood swells. The result is that the oils are, to some extent, squeezed out.

In this connection the writer has under examination samples of paving blocks treated by the "Creo-resin process," furnished by the kindness of City Engineer Erickson. These blocks seem to be well impregnated with creosote oil, reinforced by a quantity of resinous pitch, and they have every appearance of being an excellent paving material. These, with similar untreated blocks, were immersed in water on September 4th, 1900, and have now been in 60 days. At 30 days the absorption by the treated blocks was only about 33% of that of the untreated, the resinous pitch exuding but slightly; but at the end of 60 days the absorption of the treated blocks had gained considerably, as compared with those untreated, and a large amount of pitch had come to the surface, appearing in large globules adhering to the blocks. So marked was this action that it was deemed desirable to extend the experiment another month, and note further its extent.

Reverting to the original question of thorough drainage of the roadbed, it would seem unnecessary to insist on this in this advanced age of railroading, as such neglect is so destructive to the track as a whole and to the reputation of the roadmaster. It is easy to see that if the action just described takes place, it would be likely to soon exhaust any antiseptic that could be put into the timber.

(*e*) The most thorough permeation of the timber by the antiseptic is a fundamental part of the work, so far as the zinc-tannin or the Burnett process is concerned. The application of a stronger solution superficially will not make up for the lack of permeation, as it is not known that the chloride will diffuse in time. Steaming under pressure is the best and most effective means to secure through permeation, and it must be gauged or prolonged to meet the character and condition of the timber. Oversteaming sometimes will reduce the amount of absorption of the solution, but, on the other hand, the permeation will be more perfect. Thorough permeation by the steam can be best observed by noting the character and condition of the condensations blown from the retort from time to time. First will be observed the condensations caused by the steam coming into contact with the more or less cold charge; next, will follow a discharge of water tainted with the juices of the timber, increasing in its turbid and frothy condition as the steaming progresses, and then losing this character gradually and flowing off in the form of pure condensed steam or water. This last stage indicates that the steam has reached the heart of the timber, which is then in proper condition to receive

the solution, whether creosote oil, chloride solution or whatever is used. From the quantity of this highly charged water thus thrown off, the impression is that the timber has been cleared largely of its natural juices and of fermentable matter inherent therein. The vacuum drawn at the termination of steaming, of course, will still further free it from any remnants of saps, but its chief function is to draw the air and vapors from the retort and prepare the timber for the introduction and absorption of the solution, which is let in while the vacuum is still on. Mr. Rowe.

How absorption takes place when this point is reached, the following observations made at Las Vegas in 1885 will best show:

	Hewn ties.	Sawed ties.
First half-hour..............	0.42 per cent.	0.54 per cent.
Second half-hour............	0.24 " "	0.31 " "
Third half-hour..............	0.16 " "	0.07 " "
Fourth half-hour.............	0.11 " "	0.04 " "
Fifth half-hour..............	0.07 " "	0.03 " "

(*f*) The question of the injection of liberal quantities of chemicals is of great interest just now, when managers are looking to reduction of cost. The chemicals form the most costly part of the treatment, and, while it must be insisted that enough be used to get the best results, there is an extreme which cannot be passed without wastefulness. At the time the writer was in the a-b-c of this matter, he was instructed that $\frac{25}{100}$ of 1% of the weight of the timber was the minimum amount of chloride allowable. On this basis, a careful determination of the mean weight per cubic foot of the dry ties for treatment at Las Vegas was 31 lbs. or thereabout. One-quarter of 1% would be 0.075 lb. of pure chloride, or a little over 1 oz. per cubic foot of timber. In view of the statements in the preceding paragraph, it might seem to be enough. In any case, the mean absorption of the ties treated in 1885 was about $\frac{1}{4}$ lb. per cubic foot. The absorption of some of these ties probably did not exceed the minimum mentioned, and yet, these 1885 ties are being pointed to as eminently good. The strength of the chloride solution then used was 0.015, or 1½%, and the average absorption, compared to volume of timber, was about 30 per cent.

In approaching this question of quantity, the operation must be studied closely. A dry tie having a volume of 4 cu. ft. would weigh 125 lbs. A green, freshly cut tie of this volume, with all its sap, would weigh 187 lbs., having about 16 lbs. of sap per cubic foot, the sap presumably containing almost all the fermentable agents. As before noticed, a large proportion of the juices are expelled by the steaming and the vacuum, say 75%, leaving 4 lbs. of sap to be neutralized by 1 oz. of pure chloride, or a 1½% solution.

Mr. Rowe. Mr. Chanute explains that by the rule referred to the amount was later found to be too low.

Attention is called to this, with the hope that some one who is favorably situated will take up this investigation, as any proposed increase in the cost of chemicals, in the face of the calls for cheaper work now being pressed, makes it very desirable that something definite and authoritative should be determined.

(*g*) In closing his valuable paper, Mr. Chanute says: "It cannot, however, be too strongly insisted upon that the work must be well and skillfully done, for, otherwise, the results are sure to be disappointing."

This is most heartily emphasized, and it follows that skillful operators must be employed. In Germany, as Mr. Chanute states, about the only successful and satisfactory work has been done by a private firm who makes it a business and conducts it on business principles, and an important part of whose assets consists of honest work. There is no doubt that any party operating in this country on the same principles can succeed. In either case, the skilled operator is the first requisite, and it is the same with any great railroad company that decides to do its own work. In Germany, it is said that the skilled operators can be counted on the fingers of one hand, and probably the same is true in this country. In the installation of a plant of this kind, a matter of the first moment is that an inexperienced and untrained operator should no more be put in control and direction than that a college student should be put in charge of one of the big steel plants. The proposed "operator" may have read every word written on the subject of timber preservation, and, if he has escaped the lunatic asylum, he has reached but the a-b-c of the matter, and must still have intelligent training through practical contact with the work. He must have the rules fixed by an experienced teacher and be made to apply them; and, above all, he should not allow himself to go out on any theorizing excursions, as all such are likely to prove disastrous, both to himself and his employers.

(*h*) The writer is pleased to note that oak (presumably something like our white oak) is not barred out from the woods treated in Europe Regarding the selection of tie timber, it seems to be axiomatic that "the better the timber, the better the tie it will make," regardless of treatment. Experience and reason show this, and if the life of an oak tie of the best quality can be prolonged but 2 years, it is economy to treat it. Taking the white oak tie as it runs, there is a strong probability of doubling its life. The objection that the oak will not absorb sufficient to do any good, is, in the light of experience, a mistake, and is illogical, when the nature of the process and its effect is understood.

(*i*) Mr. Chanute mentions the "constant testing of chemicals, as

to strength, purity, etc.," in connection with the requirements in European practice. It is presumed that what is meant is tests which may be performed on the work during operation, where it is not always practicable, to call in the aid of the chemist. It is necessary that the operator be able to determine quickly, approximately at least, the strength of the solution, whether chloride, tannin or glue, without the elaborate processes of the chemist, as, in the course of the operations, these solutions are constantly varying. We have been indebted to Mr. Chanute in this respect, and would be glad to have him give, at length, such facts as he has gathered, couching them in such terms as would be within the comprehension of any intelligent operator. Such information would be valuable indeed. Mr. Rowe.

(*j*) Mr. Chanute's remark in relation to the exhaustion of the timber supply introduces a theme, the importance of which, in this country especially, should be impressed at all times. In the last 30 years we have seen such destruction of our great forests as seems appalling. With the exception of a small territory in northern Maine, some small areas in the South and the region of the extreme Northwest, the forests have been invaded and the most valuable timbers have been more or less cut away. In many cases, shameful waste and destructive fires aid in the devastation. The tie renewals amount to nearly 70 000 000 annually, to-day, compared with 4 000 000 required in France, and the ratio will increase as the mileage increases. Although our forests seem boundless, they are not so, relatively; and, at the present rate of consumption, the scarcity of cross-ties, now beginning to be felt, will soon be serious. A parallel to this can be cited, quicker in its consummation, but by no means so far reaching and disastrous—that of the bison, thirty years ago teeming in millions over the western plains, but now hardly a representative remaining. This is a lesson to ponder.

Ward Baldwin, M. Am. Soc. C. E.—Mr. Chanute's exhaustive *résumé* of the present practice in Europe in the preservation of wooden railway ties suggests to the speaker what is generally regarded as the next step in the evolution of railway track, namely, the use of metal ties. It is true, in general, that, as the cost of timber increases, it becomes more economical to use, first, preserved ties, and then, metal ties. Now, the statistics presented in the paper show that in Europe preserved ties can be procured at a cost which would apparently make them more economical than metal ties. It is nevertheless true that metal ties are used extensively there. The observation of the speaker, in passing over many miles of European roads laid with metal ties, is that the riding qualities of a track with metal ties are not superior to those of a track with wooden ties; and, therefore, the reason for their use would not appear to be that they give a smoother track. A comparison of the practice in Europe in the use of creosoted Mr. Baldwin.

Mr. Baldwin. ties and in the use of metal ties, now that the latter have been in extensive and growing use there for a number of years, would be interesting, and it is hoped that Mr. Chanute may add to his paper a discussion of this feature.

Mr. Howe. HORACE J. HOWE, M. Am. Soc. C. E.—The author shows, among other things, how ties are seasoned before treatment in Europe, and emphasizes the necessity for so doing in any and all of the processes which he mentions.

Possibly, seasoning for treatment is one thing and seasoning for direct track use is another. That is, the more the wood is made susceptible to the antiseptic, the better are the results, within certain limits; while the less alteration the surface undergoes, in the other case, the better will the tie stand the weather afterward.

It seems reasonable, therefore, to insist that even more care should be taken, in the latter case, to protect ties held over a season, from one cause or another, by the railroad company.

It is not uncommon to see bricks roofed over after receipt from the yard, and if that is considered economy by private concerns, why should not covering ties be economy for corporations? Bulk for bulk, the cost is about the same.

As to the saving by preserving ties, it is evident that everyone must calculate for himself. At present prices, the wolf does not seem to be at the door.

Assuming that a raw tie will last 9 years in first-class ballast (and no railroad hereabouts would consider seriously the treatment of ties unless its ballast was approximately first class), and that a treated tie will last 18 years, the following figures may serve as a basis for comparison:

One raw tie in place, 60 cents + 20 cents =	$0.80	
Interest at 4%, compounded annually for 18 years	0.82	
One raw tie in place, 60 cents + 20 cents =	0.80	
Interest for 9 years	0.34	
Total cost to maintain one raw tie for 18 years		$2.76
One treated tie in place, 60 cents + 50 cents + 20 cents =	$1.30	
Interest at 4% for 18 years	1.34	
Total cost to maintain one treated tie for 18 years		2.64

Roughly speaking, the costs are the same. No allowance is made for tie-plates. The item for treatment (50 cents) includes extra freight on that account.

If the foregoing does not focus with the facts, it is hoped that the author will indicate the reason.

O. CHANUTE, M. Am. Soc. C. E. (by letter).—The writer feels thankful to the gentlemen who have discussed his paper for bringing up a number of points regarding current European practice which seem to require further elucidation. Mr. Chanute.

President Croes is quite right in saying that the variety of notation used in Table No. 1 is puzzling, but the answer is that the table was compiled and quoted from the actual figures given to Mr. Herzenstein by the British railways, and illustrates in how many different ways it is possible to twist answers to one and the same question. In point of

DURATION OF TIES.
EASTERN (FRANCE) RAILWAY.

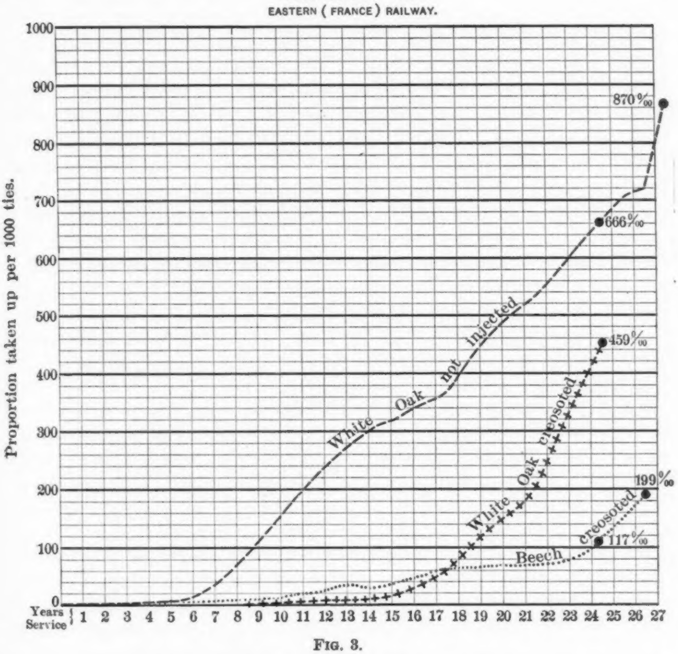

FIG. 3.

fact, the amount of creosote injected in Great Britain varies from 20 lbs. per tie on the Great Northern Railway, giving a life of 12 years, to 37 lbs. per tie on the Taff Vale Railway, with a reported life of 15 years. As all the ties are treated, there are no data to apportion the benefits due to the preliminary seasoning and to the subsequent injection in England, but the record diagram, Fig. 3, reproduced from the paper of Mr. M. V. Dufaux, showing the percentage of ties annually renewed upon the Eastern Railway of France, exhibits the fact that well-

Mr. Chanute. seasoned but untreated white oak ties average some 15 years, while the same ties, when treated, will average about 25 years in the track.

The resulting inference as to the comparative insufficiency of seasoning alone would seem to be confirmed by the facts stated by Mr. W. B. Reed, that vulcanized ties, 8 years old, taken out of the Metropolitan Street Railway, in New York City, were not fit to be used again. Vulcanizing is an excellent seasoning process, and the circumstance that it has been practically abandoned for ties would seem to indicate that the seasoning alone is relatively less efficient than the injection of chemicals.

Mr. G. W. Tillson's allusion to the Boucherie process makes it desirable to state the main reason why it was finally abandoned in France. It was found necessary to do the work in the woods, a short time after the felling, and before the bark was taken off, because, otherwise, the sap was found to have solidified so much as to make the wood much more refractory, and because there was waste of the chemicals when hewn or sawed timber was treated. The late Henry Flad, M. Am. Soc. C. E., of St. Louis, also tested the process, with some improvements, in 1882, but he too gave it up as impractical.

Mr. Mendes Cohen's mention of the Burnettizing on the Lehigh Coal and Navigation Company's road, while under his charge, recalls the fact that the writer, while on the Committee on the Preservation of Timber, in 1883, asked L. L. Buck, M. Am. Soc. C. E., to examine the ties remaining which had been so treated in 1867. They were found to have been well preserved, and greatly hardened by the process, so as to cut but little under the rail.

The differences which Mr. Samuel Whinery notes in the individual lives of untreated ties of the same species of wood, obtain with treated ties in Europe, and also in this country, but the writer has confined himself to the statement of averages. These individual differences are doubtless "due to a variation in the quality of the timber." Those ties which absorb the most antiseptics are longest preserved. This is well illustrated by the French beech, which is nearly all sap wood, which readily takes 60 to 67 lbs. of creosote per tie, and then lasts on an average 30 years, while it would decay in 4 or 5 years if laid in the track in its natural state.

Mr. S. M. Rowe is, therefore, probably in error in assuming that "the better the timber, the better the tie it will make," if he means thereby, as he seems to, that it is preferable to treat white oak rather than the inferior woods, and that heart wood is preferable to sap wood for treatment. On the Eastern Railway of France the creosoted white oak averages 5 years less life than the creosoted beech. The fact seems to be that the woods which last best untreated are close-grained and those whose sap ducts contains the most tannin, oil or resin, while the woods best fitted for treatment are rather coarse-grained and their ducts

contain more of the fermentable elements of the sap. These will absorb more of the antiseptics if seasoned. Mr. Chanute.

Mr. Rowe's statements as to the life of treated ties on the Atchison, Topeka and Santa Fé Railway are confirmed by the report of the Committee on Ties, read March 12th, 1901, in the convention of the American Railway Engineering and Maintenance-of-Way Association, which assigns to these ties an average life of 10½ to 11 years, in the track, and thereby indicates comparatively as good economical results as obtained abroad. If we estimate that these mountain pine ties, untreated, would last 4½ to 5 years, it is seen that an additional life of 6 years is given to them by the treatment, at a cost of about 15 cents each, and the additional life has therefore cost $\frac{15}{6} = 2.50$ cents a year per tie, or about one-half its value to the road. In France, on the other hand, the untreated beech would last about 5 years; creosoting, at a cost of 64.2 cents each, increases their life by 25 years, and the cost is therefore $\frac{64.2}{25} = 2.57$ cents a year per tie, leaving out all questions of compound interest, or cost of replacing in the track. This would seem to confirm the opinion of the writer that the cheaper processes are best adapted to the present conditions in the United States.

Mr. Rowe is doubtless right in advocating a larger size of tie for the future. The sizes here and abroad compare as follows:

Ordinary Standard tie in United States......	8 ft.	x 6	x 8	ins.	= 2.67 cu. ft.
Pennsylvania Railway in United States......	8.5 "	x 7	x 7	"	= 2.89 " "
First-class tie in Great Britain...........	8.92 "	x 5	x 10	"	= 3.11 " "
First-class tie in France	8.53 "	x 5.1	x 10.2	"	= 3.08 " "
First-class tie in Germany.............	8.85 "	x 6.31	x 10.25	"	= 3.97 " "

The "Baltic redwood" which is so largely used abroad, and which Mr. Rowe inquires about, the writer believes to be a species of pine. The samples which he saw looked to him very much like the short-leaf pine of the South, or the Norway pine of the North.

The writer does not believe, with Mr. Rowe, that the washing out of mineral salts will be more rapid when the tie "lies in the water all the time" than when it is alternately wet and dry. His experience is that it is the repeated soakings from rains which leach out the salts; each soaking taking up some of the chloride of zinc and each evaporation dragging some of it out. He has satisfied himself of this by many alternate soakings and drying of treated blocks, and has also succeeded in floating out by that process some of the lighter portions of creosote; the latter is, however, much more refractory. Somewhat

Mr. Chanute. similar experiments have also elicited the fact that zinc chloride does diffuse itself in timber. The analysis of a chip bored out from the very center of a tie, immediately after treatment, shows no trace of zinc; after a week a trace of the salt is shown by taking the adjoining chip, and a month or two later much more zinc is found by further boring in the same hole. The salt has been diffused by endosmosis; and it is found that after exposure for some years in the track it has been leached out by exosmosis.

Mr. A. Schneidt, while Superintendent of the Imperial Railways in Alsace-Lorraine, took up some ties which had been Burnettized in 1893, with known quantities of zinc chloride, and exposed in the track three years. He had many chips bored from them, mixed and analyzed these, and concluded that from the oak 90 to 97% had leached out, 80 to 85% from the pine, and 88% from the beech. There was yet perhaps enough of the chloride of zinc in the pine and beech to prevent the development of living organisms, but elimination slowly progressed. Partly in consequence of this investigation, the German specifications for injection have gradually been made more rigid. That of 1895 required that the zinc-creosote solution should be 3° Beaumé strong, while the 1899 specification requires it to be 3.5° Beaumé strong. The amount of solution to be injected was 6.2 lbs. per cubic foot for oak and 18.7 lbs. per cubic foot for pine and beech, while in 1899 the amount required is 6.2 lbs. per cubic foot (the same) for oak and 19.3 to 20.25 lbs. per cubic foot for pine and beech. The amount of seasoning required has also been increased. In 1895 oak was not to be injected until it had dried so as to weigh but 53 lbs. per cubic foot, beech 51.4 lbs. and pine 39.2 lbs. per cubic foot; while in 1899 it is specified that it shall not weigh more than 49.8 lbs. per cubic foot for oak, 45.1 lbs. for beech and 39.2 lbs. per cubic foot for pine.

In answer to Mr. Rowe's request, the writer herewith furnishes another appendix (D)* containing the new rules for testing chemicals and solutions adopted by the Imperial Prussian Railways. These are as yet unpublished in Germany, having been devised and adopted in 1899.

The writer does not believe, with Mr. Ward Baldwin, that the next step in this country will be to resort to metal ties. Not only would the interest on their cost at 4% be more than the annual cost of the decay of wooden ties, especially if treated, but the use of metal ties is not increasing abroad. In England they have been laid experimentally, but not adopted. In France they have been found less economical than wooden ties, mainly in consequence of wear in the fastenings and lack of stability after tamping. In Germany the writer gathered the impression that they were used, in great measure, for the sake

* For convenience, this appendix has been added to the original paper after Appendix C.

of furnishing work to the steel mills. The writer is of the opinion that the next step for American railways will be to resort to chemical preparation of wooden ties, and that this will be done on a large scale. Mr. Chanute.

Mr. H. J. Howe's estimate of the comparative economy of untreated and treated ties is not correct. Granting his mode of comparison, he has overestimated the probable cost of the raw ties to be treated. In sections where the durable woods, which last 9 years, cost 60 cents, the inferior woods suitable for injection will cost 30 to 35 cents per tie. The cost of treatment with zinc-creosote will be about 25 cents, probably including extra freight, and when the treating works are at a gathering point, such as New York or Chicago, there will be no extra freight. His comparison, therefore, should be amended as follows:

One durable tie in place, 60 + 20 cents................	$0.80
Interest at 4% compounded for 18 years...............	0.82
One renewed tie in place, 60 + 20 cents...............	0.80
Interest at 4% compounded for 9 years...............	0.34
Cost of maintaining one raw tie 18 years..............	$2.76
One treated tie in place, 35 + 25 + 20 cents...........	$0.80
Interest at 4% compounded for 18 years..............	0 82
Cost of maintaining one treated tie 18 years...........	$1.62

In point of fact, the assumed average life of 9 years for durable ties and of 18 years for treated ties are both probably overestimates for American practice.

Mr. F. A. Kummer, in closing the discussion of his paper,* raises the interesting question whether steam or compressed hot air is most efficient in preparing wood to receive an antiseptic. In England neither is used; a vacuum is produced in the cylinder and the hot creosote is then admitted; the ties being thoroughly seasoned, moisture from steaming would resist the entrance of the oil. In France the best practice is to desiccate the ties with hot air in drying ovens, and then to run them quickly into the treating cylinder. In Germany no prior steaming is used in creosoting, but this method is used in the zinc-creosote process, as the latter involves a watery solution. Last year the German railway officials questioned whether such steaming was beneficial for well air-dried ties, and made many experiments. These showed that only 2 to 11.6% of the sap contained in the seasoned wood was extracted by the steaming, and there is an inclination

* *Transactions*, Am. Soc. C. E., Vol. xliv, p. 213.

Mr. Chanute. to give it up. The results might have been quite different if the experiments had been made upon freshly-cut or half-seasoned ties, such as are now furnished for injection in the United States. The writer has made a great many experiments with various methods for increasing the receptivity of such fresh ties, but has not reached such absolute conclusions as to warrant publishing them.

Mr. Kummer, however, is mistaken in assuming that "the tannin treatment, it is claimed, completely seals the pores against the entrance of moisture from the outside." The claim really made is that the tannin treatment simply retards the entrance and the escape of moisture, so as to retain the zinc chloride somewhat longer. In point of fact the data presented at the convention of the Maintenance-of-Way Association in March, 1901, showed that on the Southern Pacific Railway the average life of removed ties, which had been treated by chloride of zinc alone, was from 6.83 to 9.16 years, while on the Atchison, Topeka and Santa Fé Railway, which used the zinc-tannin process, the average life was 10½ to 11 years, and on the Chicago, Rock Island and Pacific Railway, with zinc-tannin, the average life was 10½ to 11½ years. The chief objection which has been made to the zinc-tannin process is that microscopic examinations do not show a well-defined plug to be formed by the leatheroids. The exact value of such objection will have to be determined by actual experience on the large scale.

It is well established that both Burnettizing and the zinc-tannin process materially increase the spike-holding power of ties and retard their cutting under the rail. No exact comparison of these results can be made with results of the German zinc-creosote process, because the European rail fastenings are greatly superior to our own. Screws are very generally used; these hold the rail in close contact to the tie and quite prevent that slapping up and down of the rail which causes much of the cutting. As the zinc is the hardening element, it is not doubted that zinc-creosote does materially harden the wood. The further theory of its action is not merely as stated by Mr. H. Goldmark in the discussion of Mr. Kummer's paper "that the dead oil of tar will prevent the zinc salt, which is soluble in water, from being washed out." That theory is stated by Mr. A. Schneidt, in the paper already alluded to, as follows:

"In the watery solution of the chloride of zinc, the carbolic (phenols) acid contained in the tar oil added, is partly dissolved; and in this diluted form it penetrates the cellular tissue of the ligneous body far more readily and surely than the less readily fluid tar-oil.

"The presence of carbolic acid also produces a certain potential solubility in the resinous constituents of the wood, whereby the chloride of zinc solution is better enabled to penetrate the fatty resinous woody strata, and into the heart.

"In the judgment of chemists it may also be assumed that owing to the greatly attenuated degree of the chloride of zinc solution, and

in presence of the carbolic acid, a basic zinc 'phenylate' is formed from the chloride of zinc oxide, through the agency of the bases of the salts which occur in wood ashes; and that this 'phenylate' of zinc, being insoluble in water, favors duration by opposing the leaching out of the impregnated ties. Mr. Chanute.

"The preservative action of the dissolved carbolic acid is decidedly more potent than that of the chloride of zinc; and as carbolic acid is also much less soluble in water than chloride of zinc, the addition of a small quantity of tar-oil containing carbolic acid will also arrest the decay of the wood which absorbs it. The heavy oils of the added tar-oil do not as readily penetrate the wood as the more fluid solution of chloride of zinc when reinforced with the dissolved carbolic acid; the former oils remain in the outer woody layers of the tie, and form a very thin stratum, more or less obstructive to the entrance of water."

During the time intervening between the preparation of the writer's paper, its discussion and the writing of this rejoinder, a material change has occurred in the commercial situation; tar-oil has gone down in price in consequence of greater abundance. If this condition continues there will be an opportunity to introduce the zinc-creosote process in this country at reasonable cost, but there is still much difficulty in obtaining the quality of tar-oil which the Germans say is requisite for success with that process. Mr. Rütgers has none to spare, and it is not produced in the United States. Perhaps by analysis of various oils in the market it will be possible to obtain a supply.

We may also hope to anticipate the results to be expected from various processes of timber treatment with the aid of the United States Department of Agriculture. Professor Hermann von Schrenk, special agent for the Forestry Bureau, has recently delivered an able address, upon "Factors which Cause the Decay of Wood," before the Western Society of Engineers, and later, also another address on "Decay of Ties and Bridge Timber," before the Maintenance-of-Way Association. He is now engaged in testing the rate of decay of various samples of wood and the action of various fungi.

A very interesting paper on the "Preservation of Sleepers in England and Continental Countries" has also been published* by Mr. P. H. Dudley, who treats the subject from a botanical point of view, so that we may expect to have our knowledge increased upon the little-understood *rationale* of wood decay.

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* *Railroad Gazette*, March 8th, 1901.